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ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL AIRCRAFT

by Daniel J. Hoffman

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LANGLEY RESEARCH CENTER

HAMPTON, VIRGINIA 23665

under contract NAS1-15148

by

THE BOEING COMMERCIAL AIRPLANE COMPANY

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SEATTLE, WASHINGTON 98124

FORWARD

This report was prepared by the Boeing Commercial Airplane Company, Seattle, Washington, under Contract NAS1-15148. It is the third quarterly technical progress report covering work performed between 1 May and 31 July 1978. The program is sponsored by the National Aeronautics and Space Administration, Langley Research Center. Mr. Andrew J. Chapman and Mr. Ronald K. Clark are the NASA Technical Representatives.

This contract is being performed by the Advanced Structural Concepts organization. Key personnel associated with the program during the reporting period and their area of responsibility are:

J. E. McCarty	--	Program Manager
D. J. Hoffman	--	Technical Leader
J. O. Rakel	--	Materials
R. T. Cook	--	Quality Assurance
J. S. Chen	--	Chemical Analysis
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ENVIRONMENTAL EXPOSURE EFFECTS ON
COMPOSITE MATERIALS

D. J. Hoffman
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1.0 SUMMARY AND PROGRAM STATUS

Highlights of this quarter's activities include completion of the program design tasks, resolution of a high fiber volume problem and resumption of specimen fabrication, fixture fabrication, and progress on the analysis methodology and definition of the typical aircraft environment. Program design activities including test specimens, specimen holding fixtures, flap-track fairing tailcones, and ground exposure racks have been completed.

Difficulty was experienced in obtaining acceptable fiber volume fraction results on two of the selected graphite epoxy material systems. This problem was resolved with an alteration to the bagging procedure called out in BAC 5562. The revised bagging procedure, involving lower numbers of bleeder plies, produces acceptable results. All required laminates for the contract have now been laid up and cured.

Progress in the area of analysis methodology has been centered about definition of the environment that a commercial transport aircraft undergos. The selected methodology is analagous to fatigue life assessment.

During this reporting period the contract was modified to require deployment of all ground rack specimens early in the contract rather than the staggered schedule that had been previously shown.

Activities during the next quarter will include completion of all test specimen, fixture, tailcone, and rack fabrication as well as deployment of the long term specimens, and some baseline testing.

2.0 INTRODUCTION

The introduction of any new material system into commercial aircraft structure requires that an information data base be available to the designer in such a form that he can accept the material as a viable alternate to the current material system in use. Composite material components on aircraft in scheduled commercial service have demonstrated a viable level of confidence in current design and fabrication methods. In spite of this, the long term durability of composites exposed to actual aircraft operational environments represents a significant unknown in assessing the risk level for a production commitment to primary aircraft structure.

This contract will focus on expanding the data base for composite materials' properties as they are affected by the environments encountered in operating conditions, both in flight and at ground terminals. It is well known that absorbed moisture will degrade the mechanical properties of graphite/epoxy laminates at elevated temperatures. Since aircraft components are frequently exposed to atmospheric moisture, rain, and accumulated water, quantitative data are required showing the amount of fluids absorbed under various environmental conditions and the effect of this absorption on mechanical properties. In addition, accelerated laboratory test techniques must be developed that are reliably capable of predicting long term behavior. The study will include a task to develop an accelerated environmental exposure testing procedure and to correlate all experimental results and compare with analytical results to establish the level of confidence for predicting composite material properties.

The overall program has a duration of 11 years and is performed in three tasks as follows:

- Task I - Flight Exposure
- Task II - Ground Based Exposure
- Task III - Accelerated Environmental Effects and Data Correlation

Among the parameters to be investigated are: geographic location, flight profiles, solar heating effects, ultraviolet degradation, retrieval times, specimen types, test temperatures, and others. The experimental program includes in-flight and ground exposures of up to 10 years and will obtain mechanical, physical, and chemical data from about 10,000 specimens. A complete description of the program content was given in the first Quarterly Report, (Reference 1). The overall program is summarized schematically in Figure 2-1. The program schedule is shown in Figure 2-2. This schedule has now been revised to reflect deployment of all ground specimens at the onset of the program rather than the staggered schedule that had been employed previously.

ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL TRANSPORT AIRCRAFT

- THREE MATERIAL SYSTEMS
- LONG TERM GROUND & FLIGHT EXPOSURE DATA
- ACCELERATED LABORATORY DATA
- DURABILITY MODEL & ACCELERATED TEST PROCEDURES

TASK I FLIGHT EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- INTERIOR AND EXTERIOR EXPOSURE ON THREE DIFFERENT AIRLINES FOR TIMES UP TO TEN YEARS
- OVER 3200 SPECIMENS

TASK II GROUND EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- SOLAR AND NONSOLAR EXPOSURE AT FOUR DIFFERENT GROUND STATIONS FOR TIMES UP TO TEN YEARS
- OVER 3200 SPECIMENS

TASK III ACCELERATED ENVIRONMENTAL EFFECTS AND DATA CORRELATION

- BASELINE TESTING
- ACCELERATED TESTS TO LOOK AT THE EFFECTS OF TIME, TEMPERATURE, STRESS, MOISTURE, WEATHEROMETER, AND GROUND-AIR-GROUND SIMULATION
- OVER 2600 SPECIMENS
- ANALYTICAL MODEL FOR DURABILITY PREDICTION
- RECOMMENDED ACCELERATED TEST PROCEDURES FOR EVALUATING ENVIRONMENTAL RESISTANCE

FIGURE 2-1 PROGRAM CONTENT

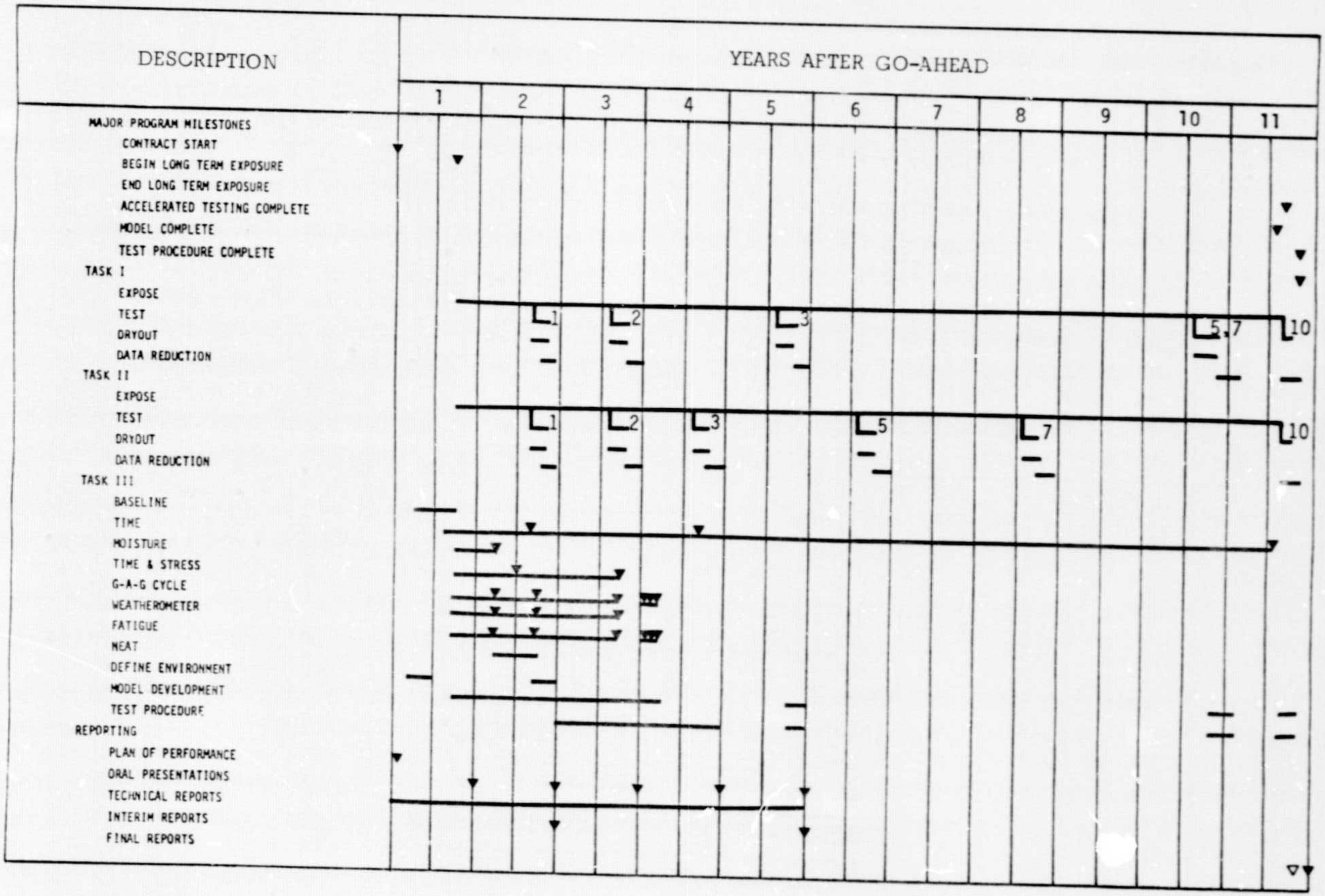


FIGURE 2-2 PROGRAM SCHEDULE

3.0 DESIGN

All design activities for the contract are now complete. Test specimen design activities were completed during the previous reporting period with drawings and explanations of the specimens shown in the First and Second Quarterly Progress Reports, (references 1 and 2 respectively).

Specimen holding fixture, mounting hardware, and ground rack designs were completed during this reporting period. The two previous quarterly reports discussed the need for these fixtures and the rationale behind various design details. Previously unpublished hardware drawings are shown in Appendix A.

4.0 FABRICATION

4.1 Test Specimens

The task of fabricating over 10,000 test specimens is well under way. Some difficulty was encountered in achieving acceptable fiber volume fraction results on both the Fiberite 1034/T300 and Narmco 5208/T300 composite systems. This problem was successfully resolved with an alteration to the bleeding and bagging procedures called out in BAC 5562. All three graphite epoxy material systems have now been accepted. The thirty-four required laminates necessary to fabricate all of the test specimens have been laid up and cured. Specimen machining is complete for the 5209/T300 specimens and under way for the Fiberite system.

Over the last several months, Boeing has experienced some difficulty in attaining acceptable fiber volume fraction results on incoming 350 F curing high resin content (42 + 2%) prepreg tape. Both the Fiberite 1034/T300 and Narmco 5208/T300 purchased for this contract had fiber volume fractions exceeding the 66% specification limit. One or more retests were run with each material with no success. Reordered batches of both materials also failed the fiber volume fraction requirement. As a result of problems with these submittals, laminate layup was temporarily suspended in order to determine the best corrective action. A revised processing technique was desired that would lower fiber volume fraction while retaining chemical, physical, and mechanical properties of BMS 8-212 graphite. Boeing Materials Technology personnel conducted a study using cure techniques differing from those shown in BAC 5562. The revised cure technique is a relatively conservative change involving bleeding and bagging techniques only and does not involve items like cure temperature or cure time.

The change involves elimination of the corprene dam and a decrease in the number of bleeder plies from 1 per .010 inch of laminate to 1 per .015 inch of laminate. Also, dry peel ply is counted as one bleeder ply. The revised bagging procedure is shown schematically in Figure 4-1. Boeing plans to revise their BAC 5562 process specification to incorporate this technique. Receiving inspection

values for the two 350 F curing graphite epoxy systems are shown in Tables 4-1 and 4-2.

The determination of an acceptable processing technique allowed resumption of laminate fabrication. All laminates have now been laid up and cured. The Fiberite laminates were inspected by through transmission ultrasonics and all appeared sound. No anomalies were detected. Process control testing for these laminates has been completed with all results considered acceptable except flexural strength. These results were considered slightly low; however an investigation indicated that the problem was one of test technique and not material quality. These laminates were released for machining based on the acceptable NDI and the remaining process control tests. Figure 4-2 shows some completed 5209/T300 test specimens undergoing weighing and measuring prior to painting.

4.2 Specimen Holding Fixtures and Mounts

An authorization to proceed with Contract Modification No. 2 calling for early deployment of all ground rack specimens was received during this reporting period. Formerly, it had been planned to employ a staggered deployment schedule like that being used for the Task I flight specimens. The modification means that more data will be available earlier in the contract. The modification also means that more fixtures and ground racks are required to house specimens since this hardware cannot be recycled as had originally been planned. Quantities have been revised to reflect the new requirements.

Fixtures for holding short beam shear/flexure specimens as well as those intended to house compression specimens are in the detail fabrication stage following a delay in the receipt of the titanium material. The stressed tension fixtures are also in the detail stage. Components necessary to assemble the unstressed tension fixtures have been procured.

Available flap track fairing tailcones have been modified to accept fixtures or specimens. Figure 4-3 shows one of the completed tailcones intended to carry short beam shear and flexure specimens (per 65C19361). Figure 4-4 shows one of the tailcones modified for carrying tension specimens (per 65C19362). Both specimens and fixtures will be painted for the final installation. Modification of the remaining tailcones will occur when the production cone becomes available. Delivery is scheduled for mid-August.

4.3 Ground Exposure Rack

Fabrication of the Task II ground exposure racks is virtually complete. Figure 4-5 shows two rack mainframes. (The rack in the foreground is folded in the shipping configuration). Insert panels will be fixed to the mainframe with quick release fasteners as shown in Figure 4-6.

PROPOSED PSD FOR BAC 5562

NOT TO SCALE

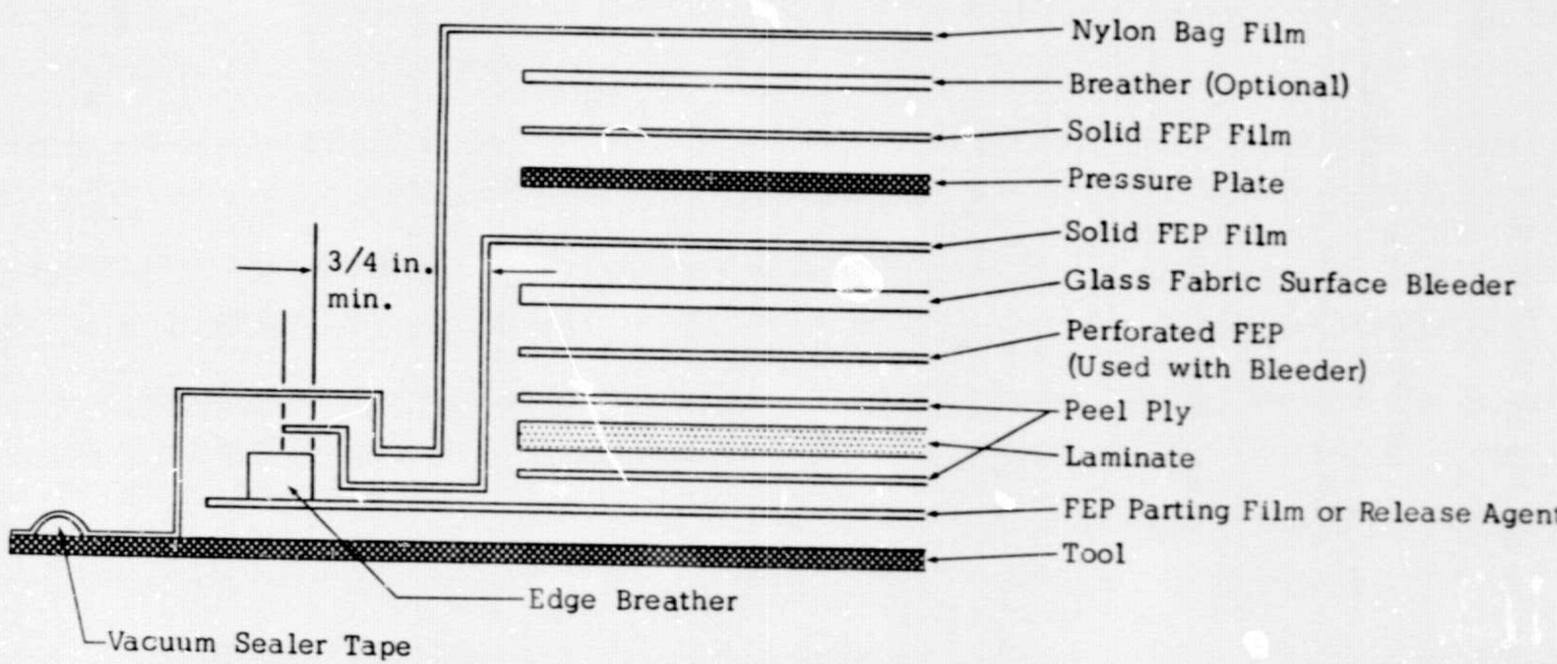


Figure 4-1 REVISED BAGGING PROCEDURE

RECEIVING INSPECTION TEST RESULTS PER BMS 8-212A

SUPPLIER AND MATERIAL NARMCO T300/5208

TYPE 1 CLASS 1 GRADE 145 BATCH/ROLL 8 1131

DATE OF MANUFACTURE 5-15-78 DATE OF RECEIPT 5-31-78

PREPREG PHYSICAL PROPERTIES

PROPERTY	RESULTS					
	INDIVIDUAL TEST NUMBER					AVERAGE
	1	2	3	4	5	
Areal Weight Graphite Only gm/m^2	145.6	145.9	145.3	——	——	145.6
Resin Content, Percent Weight	41.8	41.9	41.6	——	——	41.8
Volatiles Content, Percent Weight	.36	.25	.29	——	——	.30
Flow, Percent Weight	24.6	24.3	24.4	——	——	24.4
Gel Time, Minutes	32.42	32.83	32.50	——	——	32.58
Tack	——	——	——	——	——	PASS

LAMINATE PHYSICAL AND MECHANICAL PROPERTIES

PROPERTY		RESULTS					
		INDIVIDUAL TEST NUMBER					AVERAGE
		1	2	3	4	5	
Ply Thickness, mils		4.9 [2]	5.1 [2]	5.3 [2]	——	——	5.1
Fiber Volume, percent [1]		70.5 [3]	69.3 [3]	68.0 [3]	——	——	69.3
Void Content		——	——	——	——	——	PASS
0° Short Beam Shear Strength, ksi	$-65^\circ F$	15.3	17.1	19.6	14.3	19.8	17.2
	RT	15.4	16.5	15.5	15.0	12.9	15.1
	$270^\circ F$	8.8	9.5	10.3	11.0	10.3	10.0
0° Tensile Strength, ksi	RT	234.1	236.6	190.2	241.3	233.5	227.1
0° Tensile Modulus, msi	RT	23.6	23.0	19.5	21.5	22.1	21.9
$\pm 45^\circ$ Tensile Strength	$-65^\circ F$	25.1	25.4	27.3	25.5	26.4	25.9
	RT	20.3	24.4	24.6	24.6	24.7	23.7

NOTES

[1] Cured with 1 ply bleeder per .015" of laminate thickness.

[2] Average of 10 readings

[3] Average of 3 readings

TABLE 4.1

RECEIVING INSPECTION TEST RESULTS PER BMS 8-212A

SUPPLIER AND MATERIAL FIBERITE T300/1034

TYPE I CLASS 1 GRADE 145 BATCH/ROLL C8-361/2

DATE OF MANUFACTURE 4-25-78 DATE OF RECEIPT 5-4-78

PREPREG PHYSICAL PROPERTIES

PROPERTY	RESULTS — INDIVIDUAL TEST NUMBER 1	2	3	4	5	AVERAGE
Areal Weight Graphite Only gm/m^2	150.5	151.6	144.2	—	—	148.8
Resin Content, Percent Weight	40.7	40.8	42.7	—	—	41.4
Volatiles Content, Percent Weight	.33	.41	.31	—	—	.35
Flow, Percent Weight	21.5	21.4	21.4	—	—	21.4
Gel Time, Minutes	11.02	12.52	12.87	—	—	12.13
Tack	—	—	—	—	—	Pass

LAMINATE PHYSICAL AND MECHANICAL PROPERTIES

PROPERTY		RESULTS — INDIVIDUAL TEST NUMBER 1	2	3	4	5	AVERAGE
Ply Thickness, mils		5.4 [2]	5.2 [2]	5.0 [2]	—	—	5.2
Fiber Volume, percent [1]		62.4 [3]	63.6 [3]	—	—	—	63.0
Void Content		—	—	—	—	—	PASS
0° Short Beam Shear Strength, ksi	-65°F	16.6	23.1	21.5	19.7	23.4	20.8
	RT	15.3	16.4	18.1	19.3	17.7	17.3
	270°F	12.0	9.1	10.8	10.8	12.0	10.9
0° Tensile Strength, ksi	RT	266.3	263.2	202.3	271.3	181.9	237.0
0° Tensile Modulus, msi	RT	21.84	21.73	19.80	21.85	17.10	20.46
±45° Tensile Strength	-65°F	24.3	28.8	28.5	28.5	29.3	27.9
	RT	25.1	25.0	25.4	26.2	26.3	25.6

NOTES

[1] Cured with 1 ply bleeder per .015" of laminate thickness.

[2] Average for 10 readings

[3] Average for 3 readings

TABLE 4.2

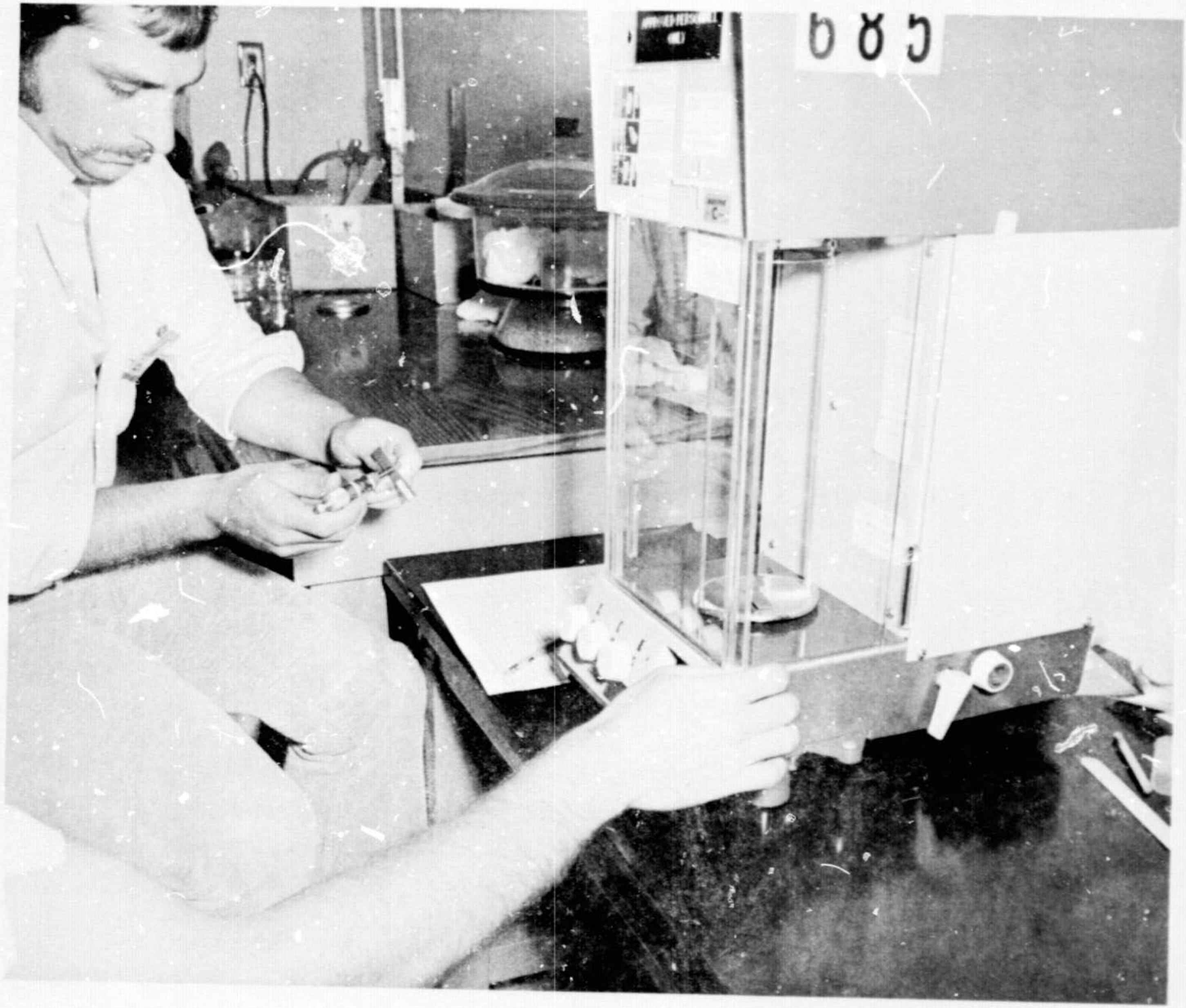


Figure 4-2 SPECIMEN MEASUREMENTS

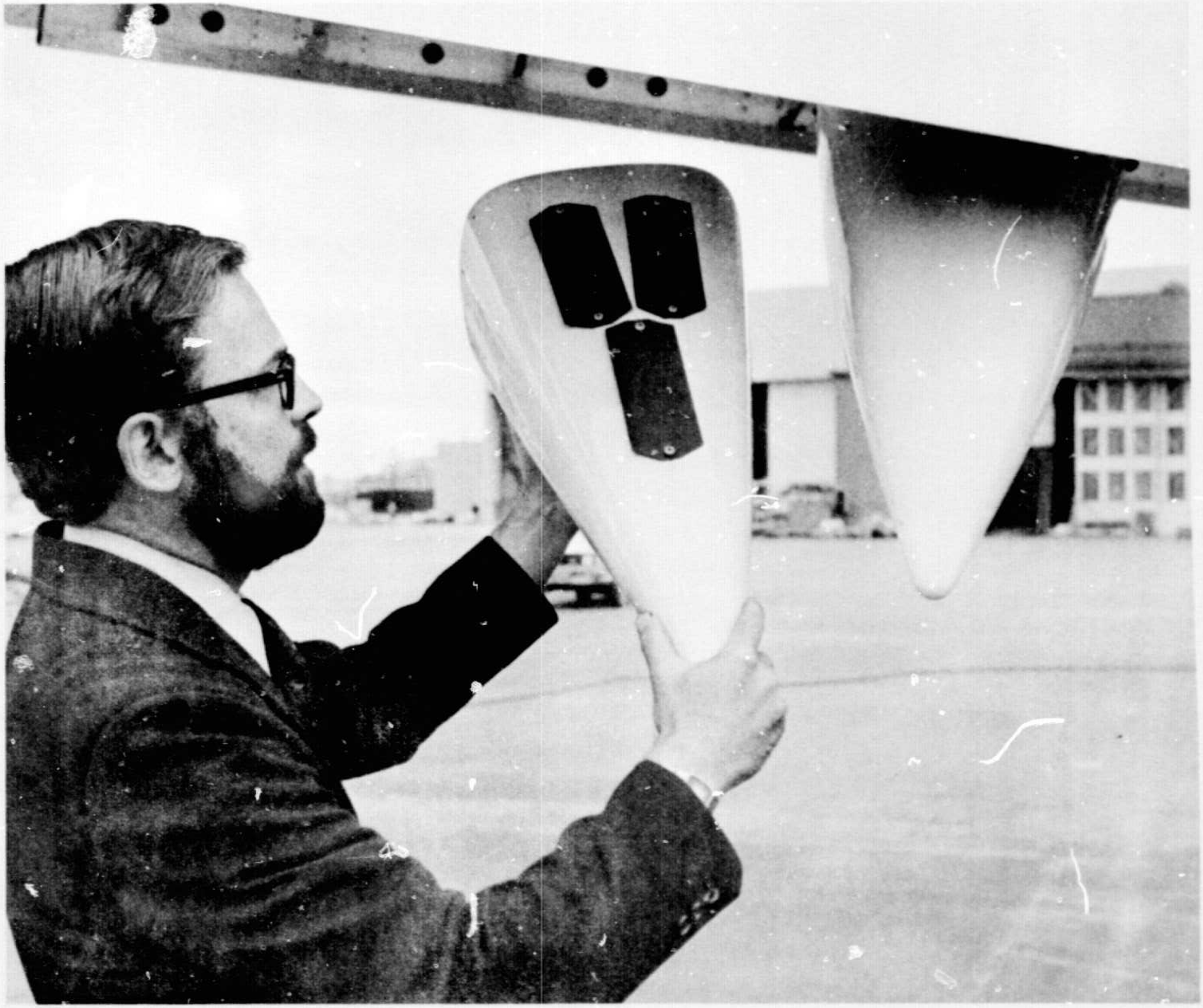


Figure 4-3 SHEAR/FLEXURE MODIFIED TAILCONE

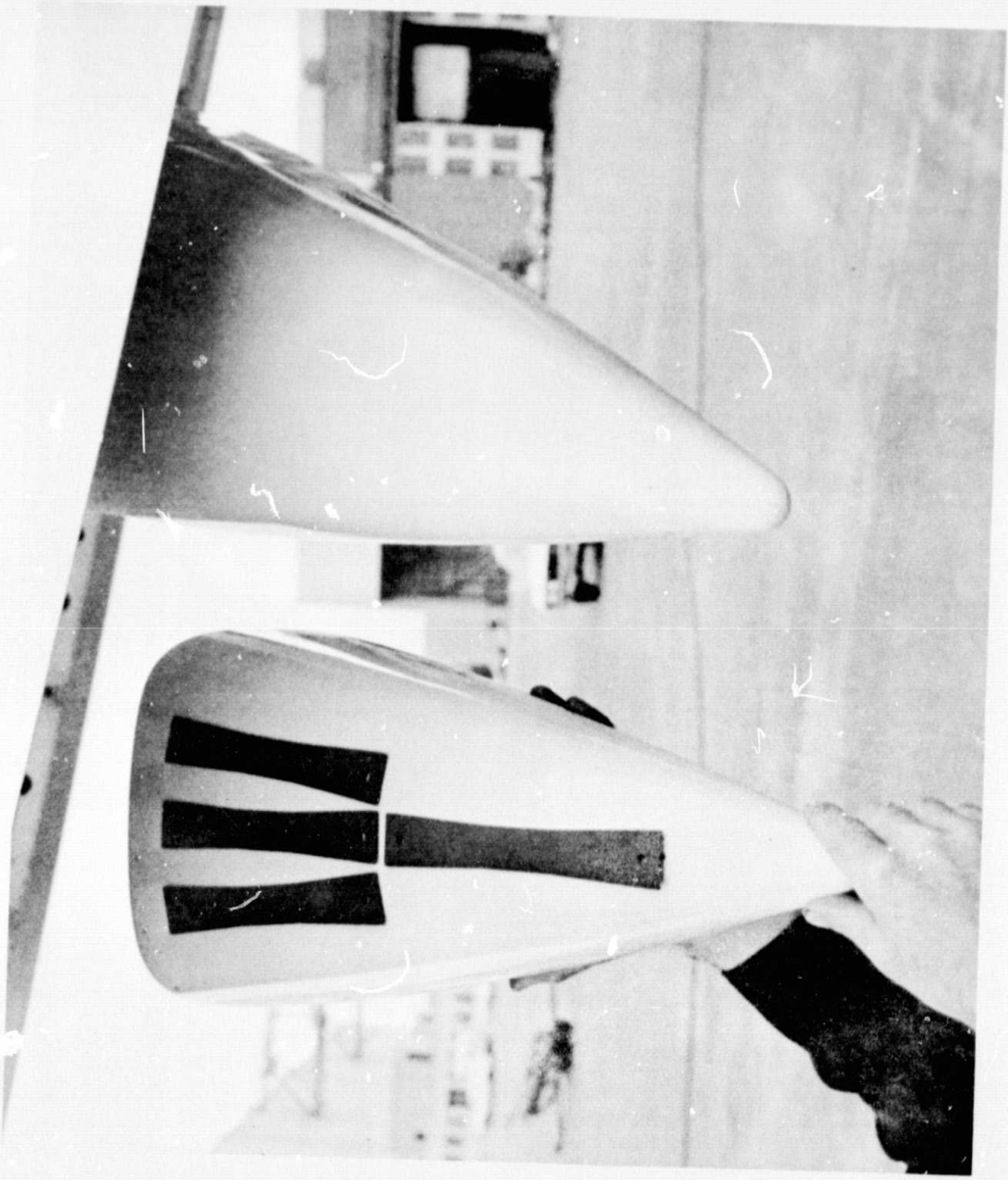


Figure 4-4 TENSION MODIFIED TAILCONE

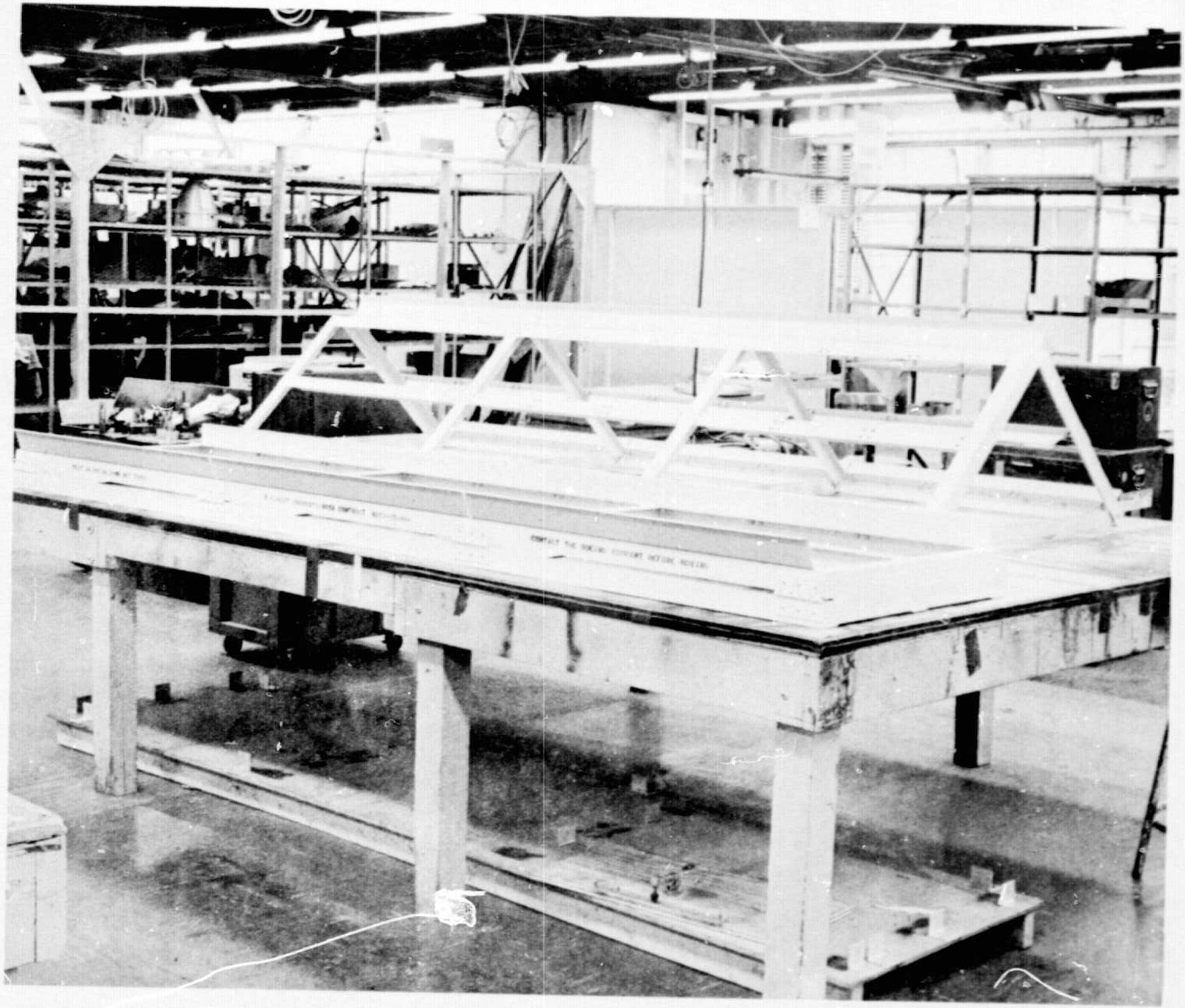


Figure 4-5 GROUND RACK MAINFRAME

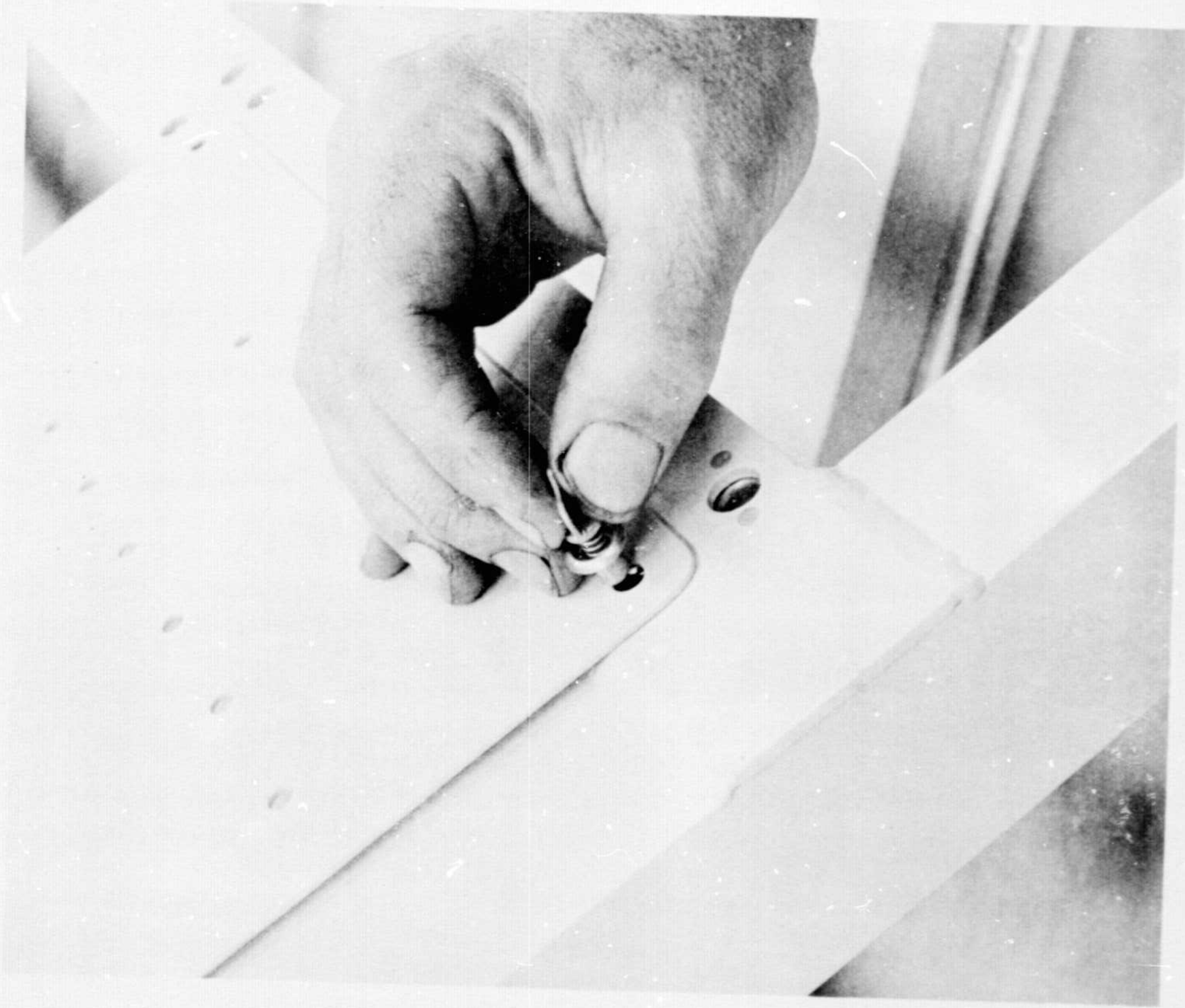


Figure 4-6 GROUND RACK SOLAR INSERTS

5.0 TEST

Physical property measurements are being recorded on the Narmco 5209/T300 and the Fiberite 1034/T300 test specimens.

6.0 ANALYSIS

Considerable progress has been made towards defining the environment to which a commercial transport aircraft is exposed. This is considered to be a critical step in the eventual prediction of composite durability. Since the exact mechanisms of long term composite degradation are unknown, the environmental definition must be flexible enough to account for a variety of degradation modes. A two phase definition that describes the "macro-environment" surrounding an entire aircraft and the "micro-environment" experienced by a particular piece of structure has been selected. The aircraft macro-environment includes factors such as calendar time and aircraft utilization. The structure micro-environment is strongly influenced by the macro-environment but also includes factors such as load, surface protection, and location on the aircraft.

A calendar time of 20 years has been selected. This selection is arbitrary but is widely accepted throughout the aerospace industry. The second area of interest, aircraft utilization, is not as simple. Different aircraft have significantly differing mission profiles. Furthermore, a fleet of a particular aircraft model will have different utilization rates and mission profiles depending on the route structure of the carrier. Finally, most aircraft will normally have a mission mix.

For example, UA Flight #44 originates and flies as shown below:

From/To	Distance (Statute Miles)
Seattle, Washington	
Portland, Oregon	132
Salt Lake City, Utah	630
Washington, D.C.	1839

Mission mix also occurs over the life of an aircraft because most aircraft are operated by more than one carrier over their 20 year design life span.

The Boeing Company has made an extensive study on Boeing Jet fleet statistics. The results of this study account for various models, utilization rates, and mission mix. This methodology is ideally suited for describing the utilization data required for an environmental durability analysis.

The initial step in this procedure is to determine the number of life flights. Figure 6-1 shows fleet statistics reduced to flight length criteria. The various utilization histories are accounted for by requiring that the aircraft be designed for short, medium, and long length flights. First, the length of the long flight is determined. The long flight length is a percentage of the maximum range based on most economical operations with a fixed percentage of design payload. The graph is entered with this long flight length and the medium and short flight lengths are then derived from the graph. Each aircraft model (i.e., 737 or 747) will have a different long flight length and hence different medium and short lengths. The requirement to design for long, medium, and short flights on each aircraft, takes into account different ways in which a particular model may be used.

Figure 6-2 shows average utilization in terms of flight hours per day as a function of flight length. The curve shows that aircraft with short flight lengths have lower average utilizations than those being flown on long flights. This is due to a variety of reasons including increased ground time requirments, passenger load and unload, galley servicing, etc. It is also due to the route structure that a short range aircraft conventionally flies as opposed to that of a long range aircraft. Each of the three flight lengths determined from Figure 6-1 is entered on Figure 6-2, resulting in three average utilization figures for each model aircraft. Knowing the flight length and the utilization rate per day, one can calculate the flights for the 20 year time span equal to utilization rates times 20 years divided by average flight length. This calculation has been performed and reduced to a design curve in Figure 6-3. To use this curve, one need only determine the design criteria for the long flight in hours, and entering the curve with this value determines flights for all three flight lengths.

Once the number of flights has been determined, the next step is to ascertain when the aircraft flies and when it sits on the ground. Figure 6-4 shows the various possibilities. The day flier is typical of most short range aircraft and to a lesser degree of all aircraft. Curfew requirements on many of the worlds major airports, limits the number of arrivals and departures occurring between approximately midnight and 6 AM. Short range aircraft tend to operate as feeder airlines and do most of their flying during the daytime hours.

The level line curve is representative of freighter aircraft and the combined passenger-freighter aircraft.Basically, the utilization remains constant throughout the 24 hour period. The night flying aircraft is a less prevailant case and probably limited largely to long range aircraft. Trade studies are being performed at this time to determine whether or not some of these profiles can be eliminated from further analysis. This data coupled with a particular airline route structure (i.e., climate) will determine the aircraft macro-environment. This macro-environment must now be modified to account for solar heating,

solar radiation, surface protection and the other factors discussed earlier. This work is continuing.

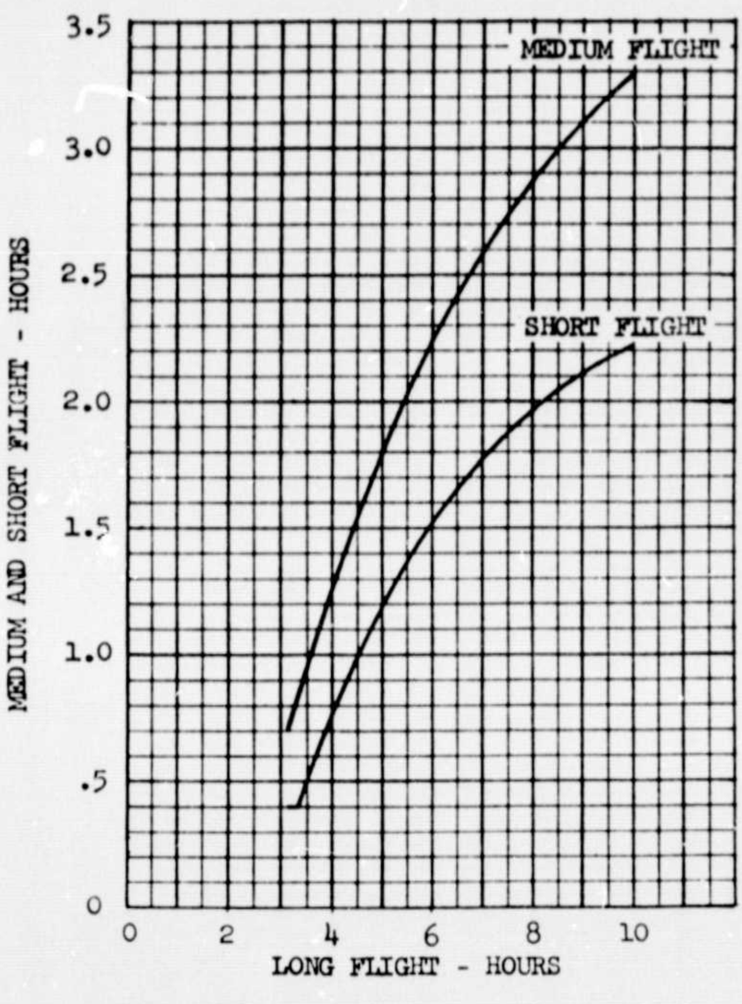


Figure 6-1 FLIGHT LENGTH

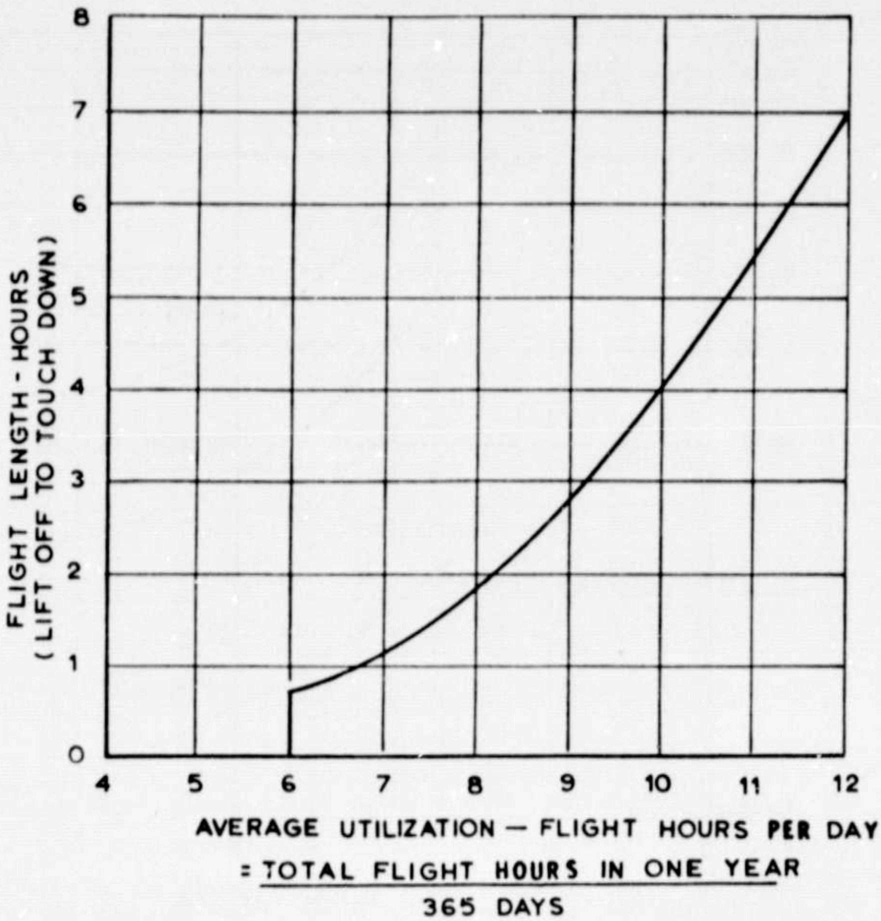
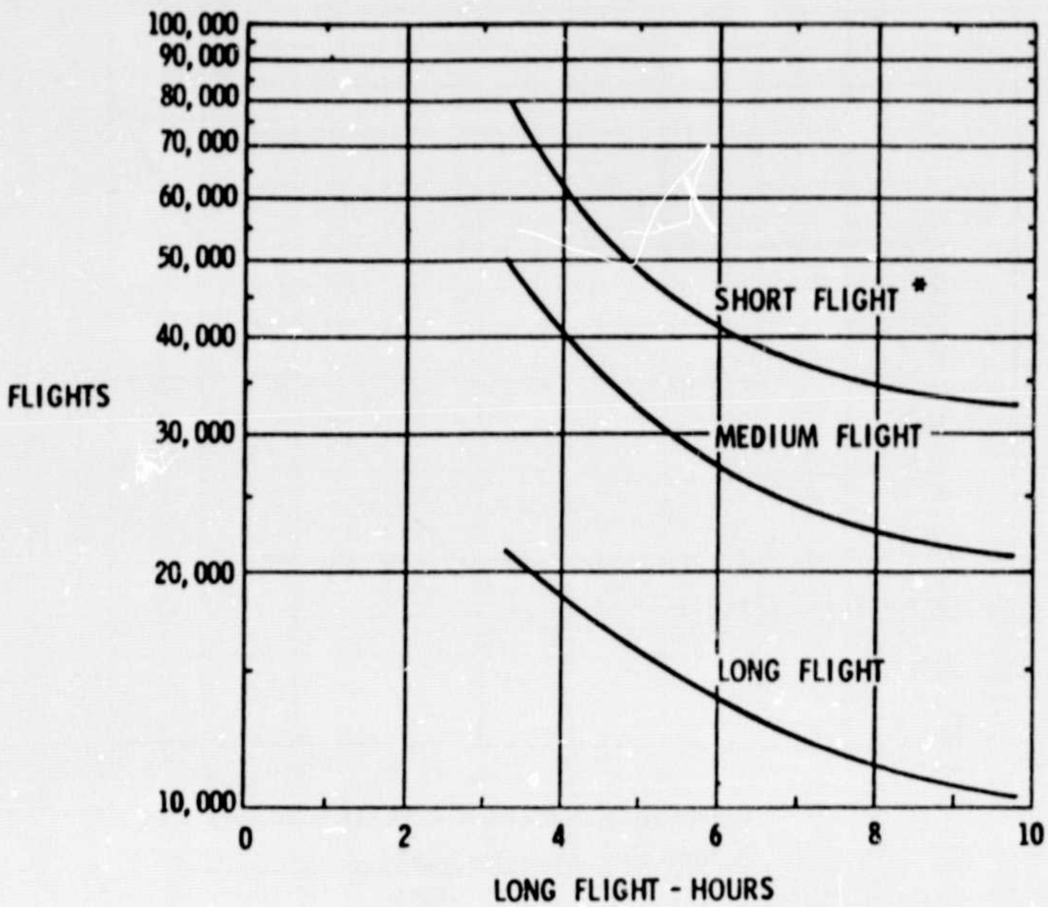


Figure 6-2 AIRPLANE DAILY UTILIZATION



* 5000 flights have been added for training.

Figure 6-3 NUMBER OF FLIGHTS

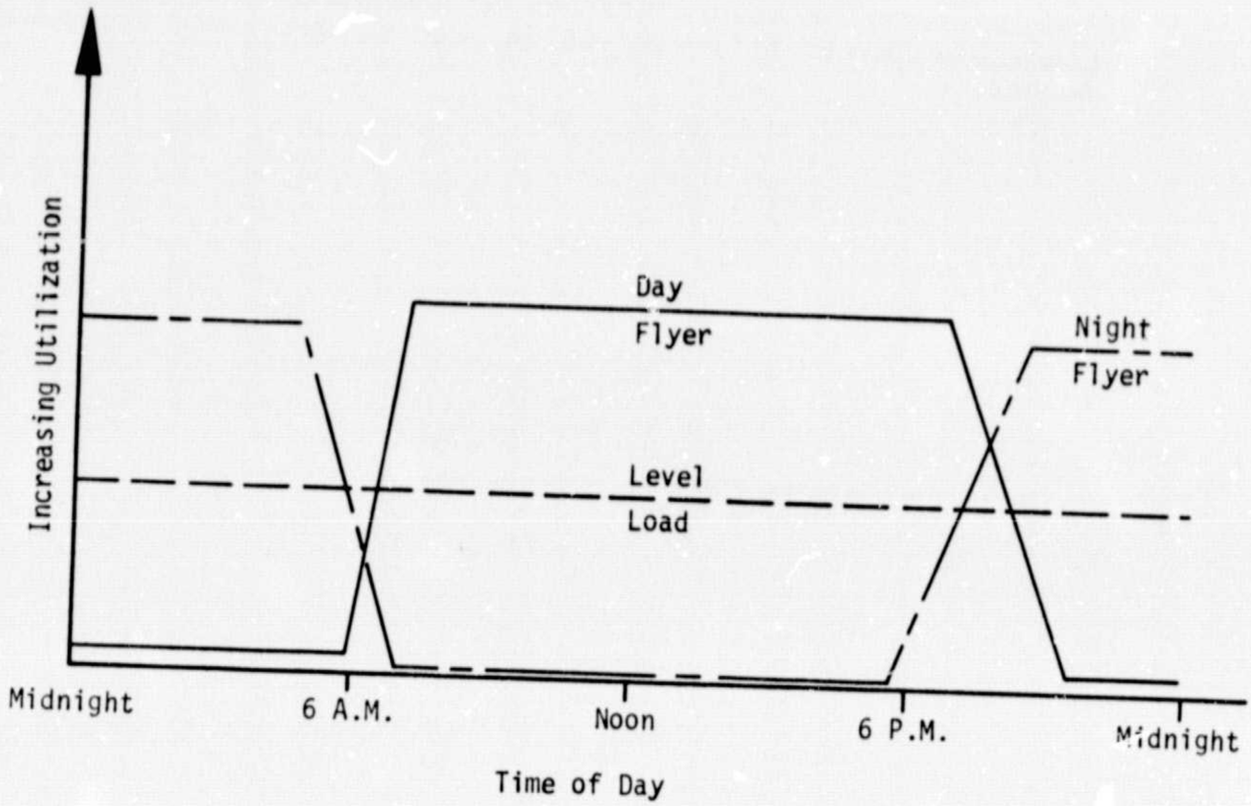


Figure 6-4 TYPICAL AIRCRAFT UTILIZATIONS

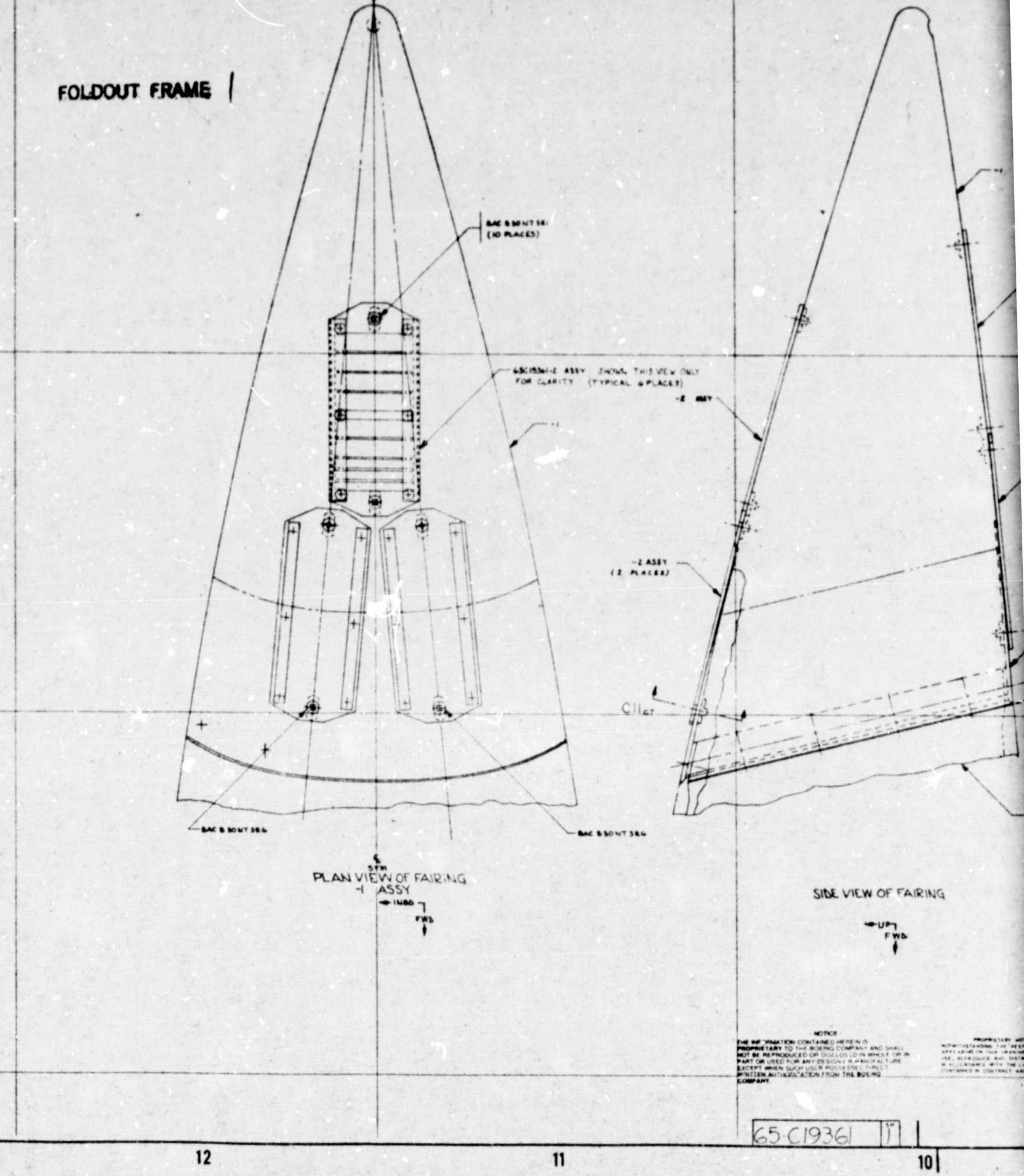
7.0 REFERENCES

1. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, First Quarterly Progress Report.

2. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Second Quarterly Progress Report.

APPENDIX A

TEST SPECIMEN HOLDING FIXTURE AND GROUND RACK DRAWINGS


FOLDOUT FRAME
BAC B30NT38-1 (10 PLACES)
65C19361-2 ASSY SHOWN THIS VIEW ONLY FOR CLARITY (TYPICAL 4 PLACES)
-1
-2 ASSY
-2 ASSY (2 PLACES)
BAC B30NT38-6
BAC B30NT38-6
℄ STA
PLAN VIEW OF FAIRING
-1 ASSY
FWD
SIDE VIEW OF FAIRING
UP
FWD
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65-C19361
12
11
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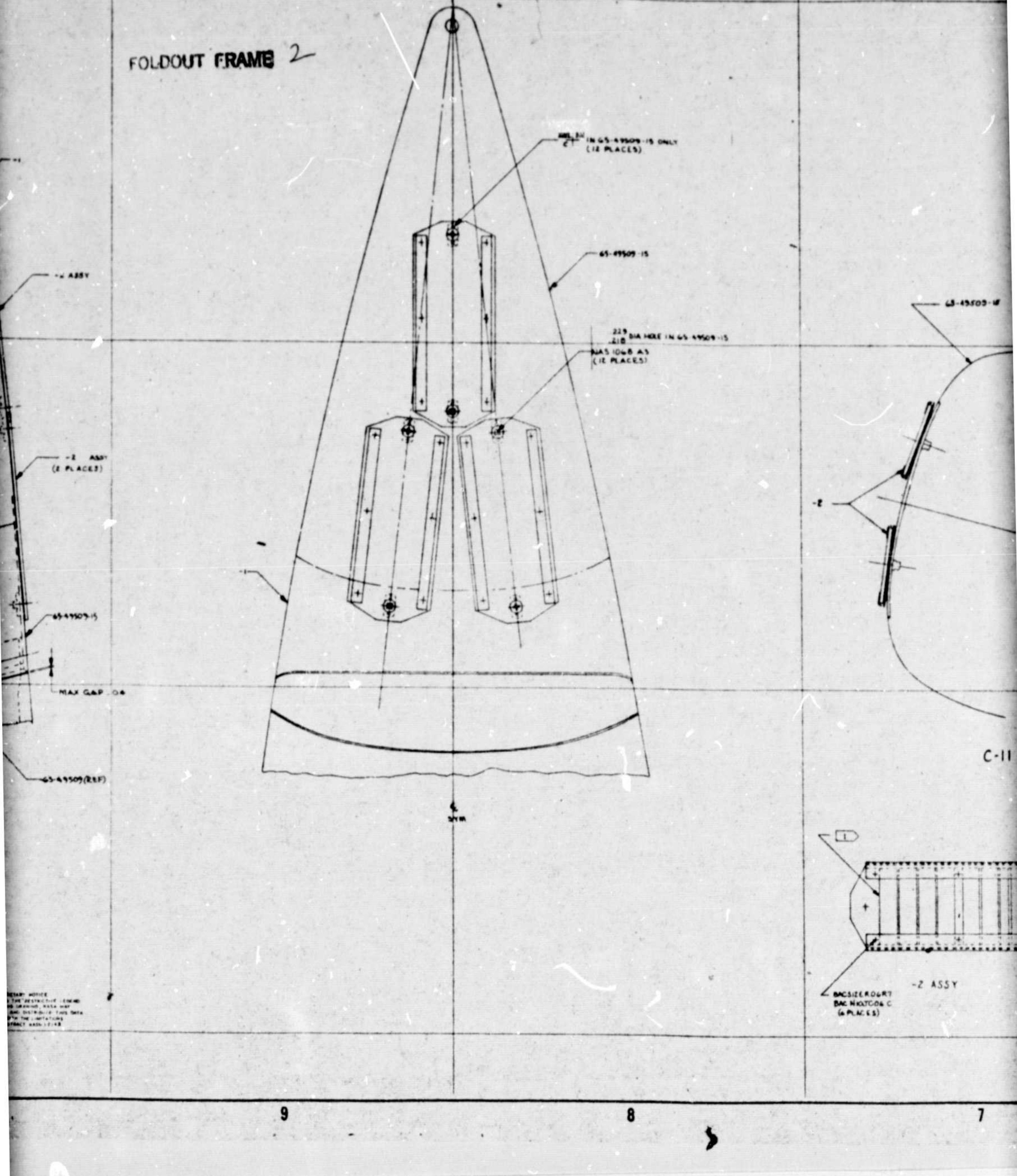
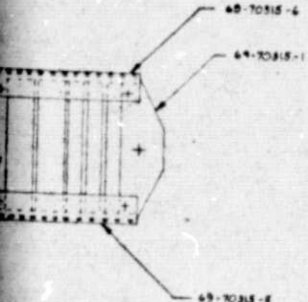
FOLDOUT FRAME 2



FOLDOUT FRAME 3

C-11



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									✓	2	BAC
									-2	4	BAC
									-2	6	BAC
									-2	1	69-70
									-2	1	69-70
									-2	1	69-70
									✓	1	65-49
									✓	6	
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RELEASE											

65-C19361 SH 1

7 6 5

FULL SIZE METAL OR MYLAR COPIES OF THIS DRAWING ARE AVAILABLE FOR SHOP USE

B BEND
DN DOWN
OML OUTSIDE MOLD LINE
IML INSIDE MOLD LINE
℄B CENTERLINE OF BEND

.250 .260/.247 DIA TOOL HOLE (USE OPTIONAL)

DIMENSIONING & TOLERANCING PER USAS Y14.5
PART MARKING PER BAC 5307
SEE BACD 2097 FOR SURFACE ROUGHNESS
FORM, PUNCH, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
BOLT & NUT INSTALLATION PER BAC 5009
MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 5001
SST MATERIALS SUBSTITUTIONS & MANUFACTURING PROCESSES PER D6-19736
FOR FINISH CODES, SEE DOCUMENT D0-5000 &/OR D6-5000

INSTL STD PER BAC 5004, FLUID TIGHT PER BAC 5047
BASIC CODE — ENCLOSED: FLUID TIGHT; OPEN: STANDARD
DIA DASH NO.
MFD HEAD LOC: N: NEAR SIDE; F: FAR SIDE
DIMPLE/CSK INFO: D: DIMPLE; 2: NO. SH DIMPLED; C: CSK INSTRUCTION; 2 LINES: TOP: MFD HD, BOTTOM: DRIVEN HD
SPOT WELD OPT
LENGTH DASH NO.
NOTE: PROTRUDING HD RIVETS DRIVEN FLUSH. D/C INFO (2 LINES) APPLIES TO DRIVEN HD ONLY
HOLE LOCATION FOR 1/8 DIAMETER RIVET
HOLE LOCATION FOR 1/4 DIAMETER BOLT
FWL: BAC 8/5 68

FOLDOUT FRAME 4

▷1 INSTALL GR/EP TEST SPECIMENS SUPPLIED BY ENGINEERING

-1	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MK	REV LTR
✓	10	BAC B30NT 3R1	BOLT						
✓	2	BAC B30NT 3R6	BOLT						
-2	4	BAC S12ER06 R7	SCREW 100° CSK HD						
-2	6	BAC N10JC 06C	NUT						
-2	1	69-70315-6	OPPOSITE -5						
-2	1	69-70315-5	ANGLE RETAINER						
-2	1	69-70315-1	PLATE ASSEMBLY						
✓	1	65-49509-15	TAILCONE ASSY FLAP FAIRING						
✓	6	-2	SPECIMEN HOLDER ASSY				F25.01		
-	—	-1	TAIL CONE ASSY	B12			F25.01	m	

LIST OF MATERIAL

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NEXT ASSY	USED ON	DCT NO	SERIAL NUMBER
-	-		TEST ONLY

APPLICATION

CONTRACT NO NAS 1-15148

DWG ORIG BY (GROUP) ADVANCED COMPOSITES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 2° DECIMALS ±.03
RIVET & BOLT EDGE MARGINS ±.05
SHEET METAL CORNER RADII: INTERNAL .16 $\frac{.19}{.16}$; EXTERNAL .22 $\frac{.25}{.00}$
BEND RADII: ±.01 ON .03 & .06; ±.03 ON .09 & GREATER

		DATE
DRAWN	CAMPAROTA, SAL	
CHECKED		
STRESS		
ENGR		
GROUP		
PROJ		

THE BOEING COMMERCIAL

TAILCONE TEST

CODE IDENT NO 81205

SCALE

4 3 2

2

FASTENER SYMBOL CODE

[illegible]

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVAL

5 FOLDOUT FRAME

D

C

B

65C19361 | 1

NOTICE

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NOTWITHSTANDING THE RESTRICTIVE LEGEND APPEARING ON THIS DRAWING, NASA MAY USE, REPRODUCE AND DISTRIBUTE THIS DATA IN ACCORDANCE WITH THE LIMITATIONS CONTAINED IN CONTRACT NAS1-15148

NEXT ASSY	USED ON	SECT NO	SERIAL NUMBER	PART NUMBER	RELEASE COLUMN INDICATOR	DRAWING SHEET NUMBER	REV LTR
-	-		TEST ONLY	-1			

APPLICATION

CONTRACT NO NAS 1-15148

DWG ORIG BY (GROUP) ADVANCED COMPOSITES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 2° DECIMALS ±.03
RIVET & BOLT EDGE MARGINS ±.05
SHEET METAL CORNER RADII INTERNAL 16 19/16; EXTERNAL 22 25/00
BEND RADII ±.01 ON .03 & .74; ±.03 ON .09 & GREATER

DRAWN CAMMAROTA, SAL
CHECKED
STRESS
ENGR
GROUP
PROJ

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION RENTON WASH

TAILCONE ASSY-ENVIRONMENTAL TEST, SHEAR & FLEXURE

CODE IDENT NO 81205 | SIZE J | 65C19361

SCALE 1/1

DRAWING RECORDS CLERK

2

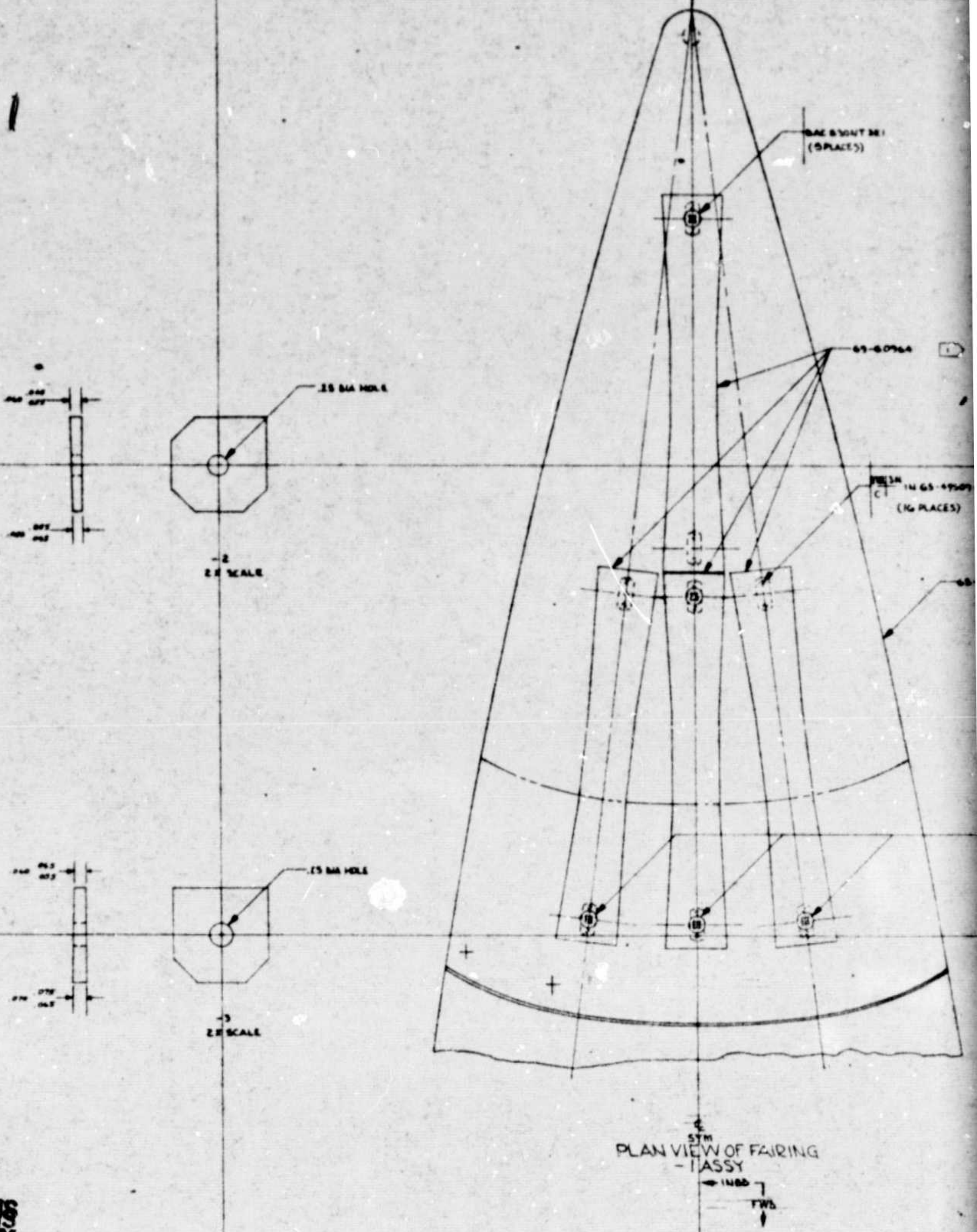
PCM

24

65C19361 SH1

FIGURE A-1

FOLDOUT FRAME 1



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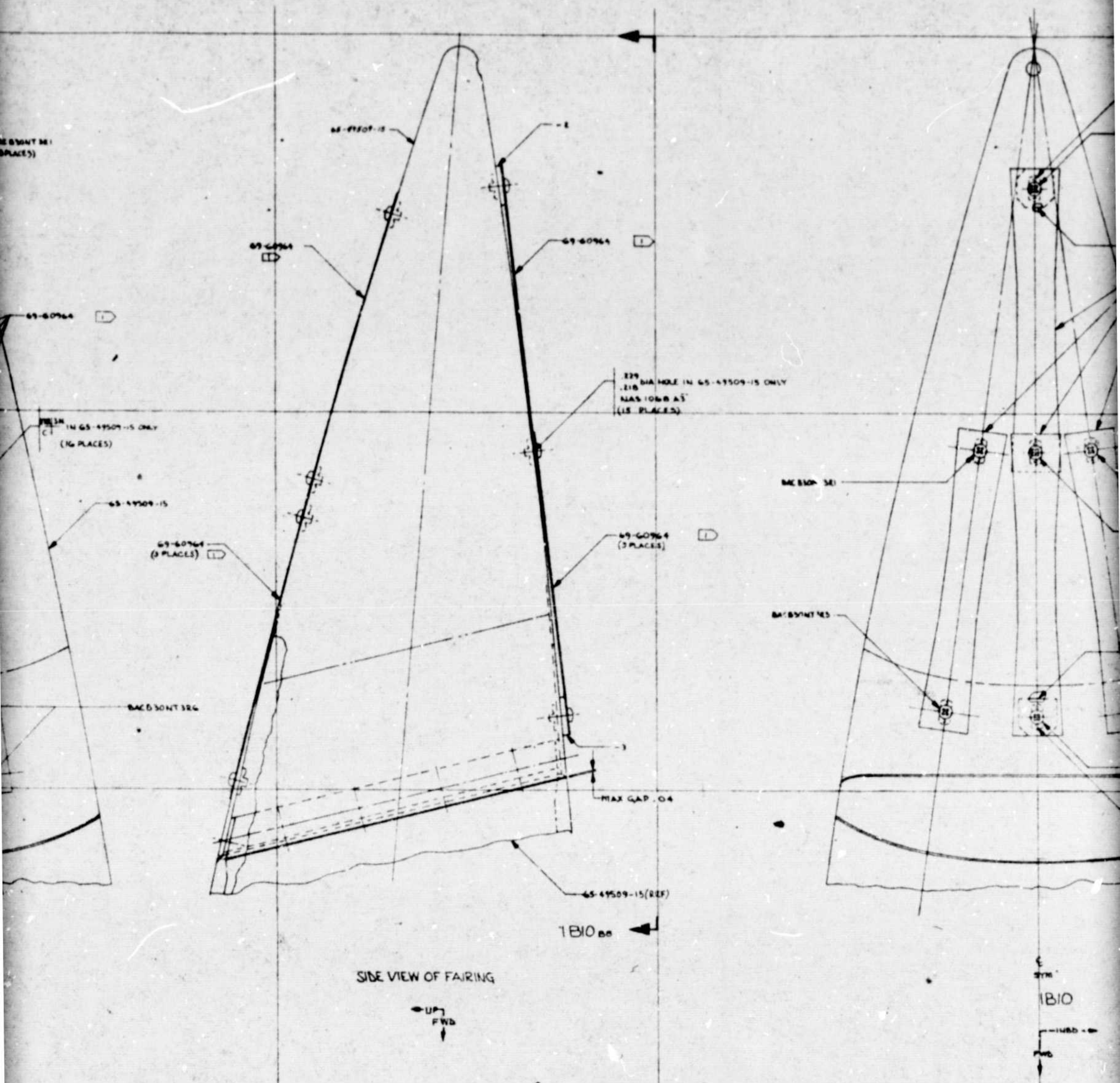
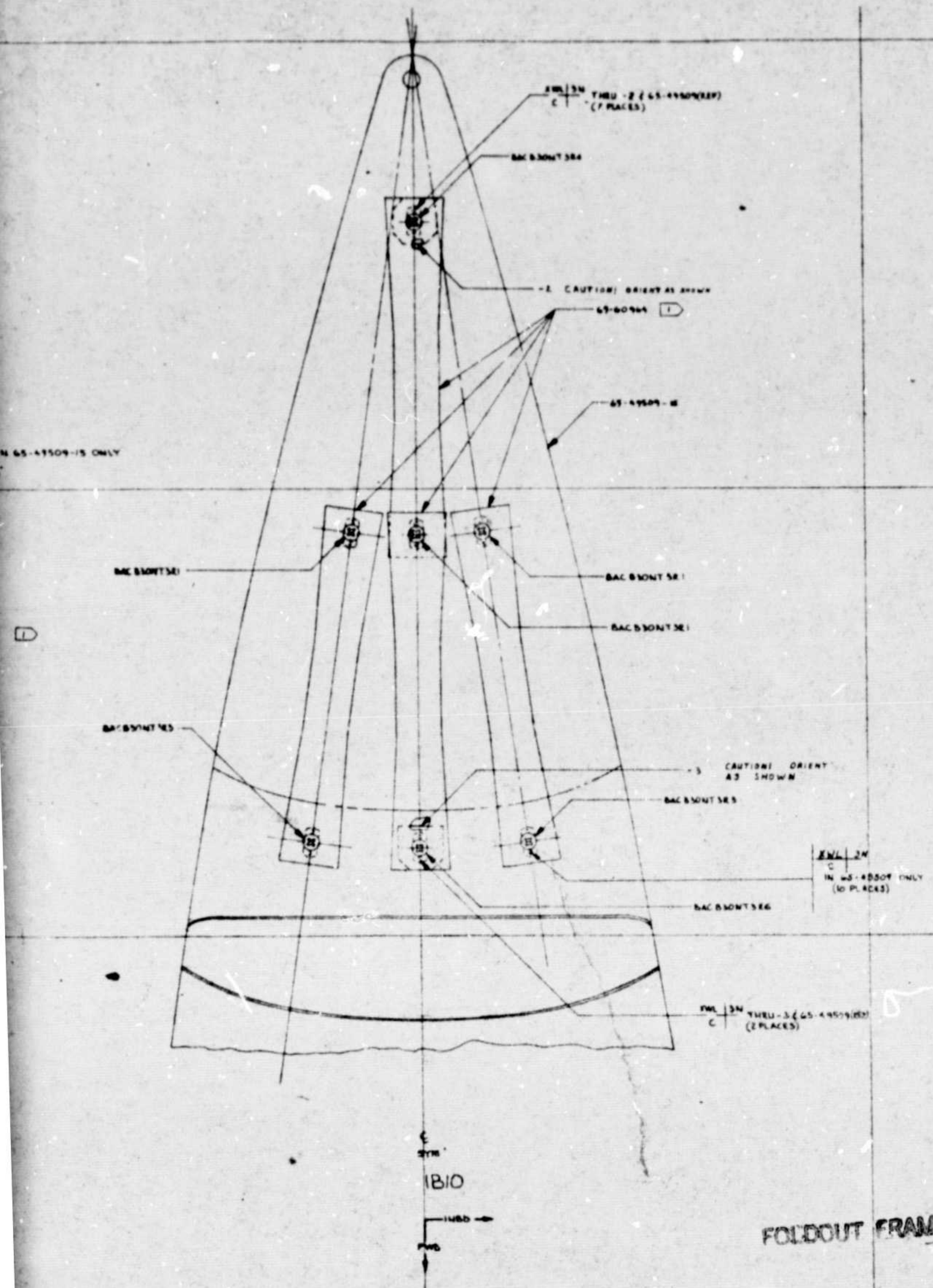
11 10 9



2 FOLDOUT FRAME

65-C19362 SH 1

11 10 9



FOLDOUT FRAME 3

1. INSTALL GR/EP TEST SPECIMEN SUPPLIED BY ENGR
2. GLASS FABRIC REINFORCED PLASTIC PER BMS 8-79 CLASS I, TYPE 181. FABRICATE PER BAC 5410

FOLDOUT FRAME 4

-1	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE
✓	8	BACB30NT3K1	BOLT	
✓	2	BACB30NT3K3	BOLT	
✓	1	BACB30NT3K4	BOLT	
✓	4	BACB30NT3K6	BOLT	
✓	1	65-49509-15	TAIL CONE ASSY FLAP FAIRING	
✓	8	69-60564	TENSION SPECIMEN	
✓	1	-3	FILLER - TAPERED	C10
✓	1	-2	FILLER - TAPERED	B10
–	–	-1	TAIL CONE ASSY	B12

RELEASE

LIST OF MATERIAL

65-C19362

DIMENSIONING & TOLERANCING PER USAS Y14.5

PART MARKING PER BAC 5307

SEE BACD 2097 FOR SURFACE ROUGHNESS

FORM, PUNCH, STRAIGHTEN & FIT METAL PARTS PER BAC 5300

BOLT & NUT INSTALLATION PER BAC 5009

MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 5005

SST MATERIALS SUBSTITUTIONS & MANUFACTURING PROCESSES PER D6-19736

FOR FINISH CODES, SEE DOCUMENT D2-5000 & CB D6-5000

FASTENER SYMBOL CODE

INSTL. STD. PER BAC 5004; FLUID TIGHT PER BAC 5047

BASIC CODE — ENCLOSED = FLUID TIGHT, OPEN = STANDARD

DIA DASH NO. · MFD HEAD LOC. · N: NEAR SIDE · F: FAR SIDE

DIMPLE/CSK INFO · SPOT WELD OPT · LENGTH DASH NO.

HOLE LOCATION FOR 1/16 DIAMETER RIVET

HOLE LOCATION FOR 1/4 DIAMETER BOLT

ORIGINAL PAGE IS
OF POOR QUALITY

5 FOLDOUT FRAME

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PROPRIETARY NOTICE

NEXT ASSY	USED ON		SERIAL NUMBER	PART NUMBER		DRAWING SHEET NUMBER	REV LTR
—	—		TEST ONLY	-1			

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

CONTRACT Nº NAS 1-15148

DWG ORIG BY GROUP: ADVANCED STRUCTURAL CONCEPTS

DRAWN: CASTAGNETA, S

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION RENTON, WASH

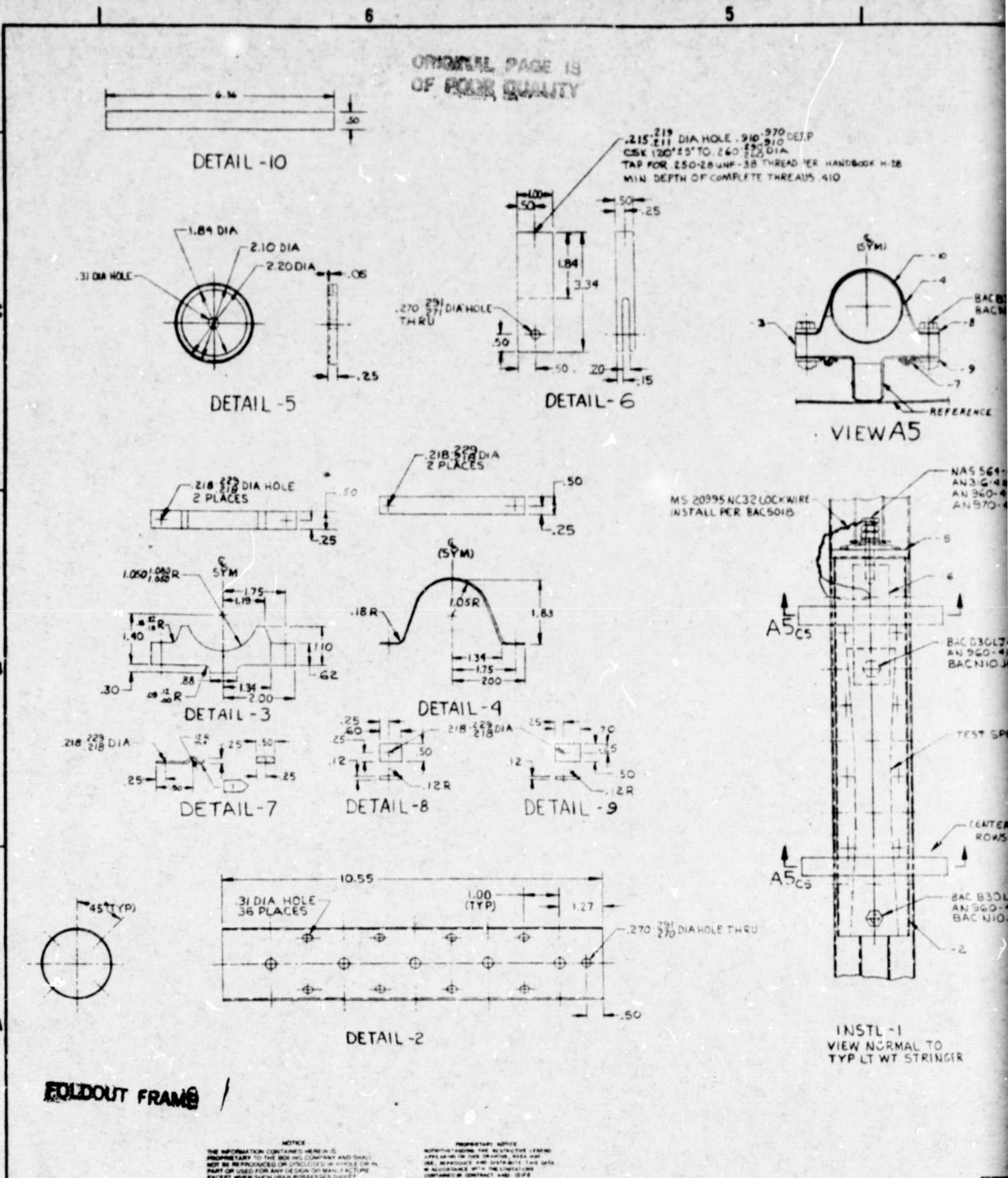
TAILCONE ASSY -
ENVIROMENTAL TEST,
TENSION

SIZE J 65C19362

PCM

25

FIGURE A-2



FOLDOUT FRAME 1

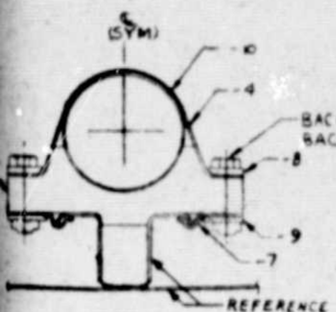
1 4 3 2

FOLDOUT FRAME 2

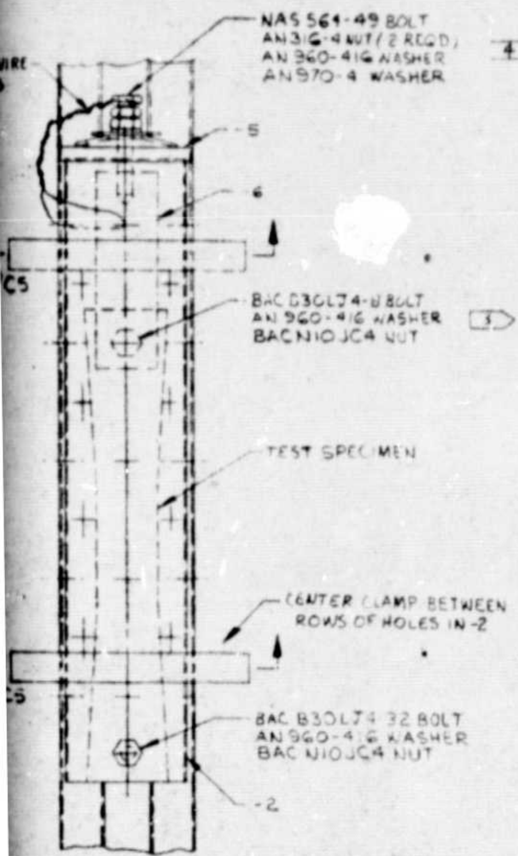
DEEP

D PER HANDBOOK H-28
EADS .410

DIMENSIONING & TOLERANCING PER USAS Y14.5
PART MARKING PER BAC 5307
SEE BACD 2097 FOR SURFACE ROUGHNESS
FORM, PUNCH, STRAIGHTEN & FIT METAL PARTS PER BAC [illegible]
BOLT & NUT INSTALLATION PER BAC [illegible]
MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC [illegible]
SET MATERIALS SUBSTITUTIONS & MANUFACTURING PROCESSES PER D6-[illegible]
FOR FINISH CODES, SEE DOCUMENT D6-[illegible] A/OR D6-5000



VIEW A5



INSTL -1
VIEW NORMAL TO
TYP LT WT STRINGER

1 AFTER F20.02:
COAT THIS REGION WITH UNICHROME
AVOID INTERFERENCE
WITH RADIUS FILLER

2 CHROMIC ACID ANODIZE ONLY

3 INSTALL FASTENER WIT[H] WET
BMS 5-79 SEALANT PER BAC 5000

4 INSTALL FASTENER WITH WET PRIMER

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OF POOR QUALITY

	✓	1		DISK SPRING		SCHNORR .57 OD x .56 ID x .042 OR EQUIVALENT			
	✓	1	NAS 564-49	BOLT					
	✓	1	BACB30LJ4-8	BOLT					
	✓	1	BACB30LJ4-32	BOLT					
	✓	1	AN970	WASHER					
	✓	2	-10	CUSHION		.060 x .50 x 4.36 RUBBER PER BMS 1-11	–		
	✓	4	-9	FILLER		.12 x .50 x .60 2024-T3 AL BAR PER QQ-A-225/6	–	F18.03	
	✓	4	-8	FILLER		.12 x .20 x .70 2024-T3 AL BAR PER QQ-A-225/6	–	F18.03	
	✓	4	-7	CLIP		.040 x .50 x 1.6 301 CRES PER MIL-S-5059 ½ HARD	–	F20.02 1	
	✓	1	-6	CLEVIS		.50 x 1.0 x 3.14 2024-T3 AL BAR PER QQ-A-225/6	–	F18.03 2	
	✓	1	-5	CAP		.25 x 2.20 DIA 2024-T3 AL BAR PER QQ-A-225/6	–	2	
	✓	2	-4	CLAMP		.012 x .50 x 7.0 COMMERCIALLY PURE Ti SHT PER MIL-T-9046	–	F20.02	
	✓	2	-3	SADDLE		.50 x 1.3 x 4.0 PHENOLIC	–		
	✓	1	-2	TUBE		2.0 OD x .028 WALL COMMERCIALLY PURE Ti TUBE PER ASTM B338	–	F20.02	
	–	–	-1	INSTL					
	-1	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT TR	FINISH	PT-MK
RELEASE	LIST OF MATERIAL								

SH

4 3 2

FOLDOUT FRAME 3

AFTER F20.02:
COAT THIS REGION WITH UNICHROME
AVOID INTERFERANCE
WITH RADIUS FILLER

CHROMIC ACID ANODIZE ONLY

INSTALL FASTENER WITH WET
BMS 5-79 SEALANT PER BAC 5000

INSTALL FASTENER WITH WET PRIMER (F20.04)

MATERIAL AND SPECIFICATION	HT TR	FINISH	PT MP	REV LTR
...NORE .17 OD x .56 ID x .062 ...R EQUIVALENT				
...0 x .50 x 6.36 RUBBER PER ...AS ...	–			
... x .50 x .60 ...24-T3 AL BAR PER QQ-A-225/6	–	F18.03		
... x .50 x .70 ...24-T3 AL BAR PER QQ-A-225/6	–	F18.03		
...0 x .50 x 1.6 CRES PER MIL-S-5059 ¼ HARD	–	F20.02 1		
... x 1.0 x 3.14 ...24-T3 AL BAR PER QQ-A-225/6	–	F18.03 2		
...5 x 2.20 DIA ...24-T3 AL BAR PER QQ-A-225/6	–	2		
... x .50 x 7.0 COMMERCIALLY ...RE Ti SHT PER MIL-T-9046	–	F20.02		
...0 x 1.3 x 4.0 ...HENOLIC	–			
...0 OD x .028 WALL COMMERCIALLY ...RE Ti TUBE PER ASTM B338	–	F20.02		

NEXT ASSY	USED ON	SECT NO	SERIAL NUMBER	PART NUMBER	RELEASE COLUMN INDICATOR	DRAWING SHEET NUMBER	REV LTR

APPLICATION

CHANGED BY: CONTRACT NO NAS1-15148

DWG ORIG BY (GROUP): ADVANCED STRUCTURAL CONCEPTS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ± 2° DECIMALS ± .03
RIVET & BOLT EDGE MARGINS ± .05
SHEET METAL CORNER RADII
INTERNAL
EXTERNAL
BEND RADII
± .01 ON .03 & .06
± .03 ON .09 & GREATER

DRAWN
CHECKED
STRESS
SNGR
GROUP
PROJ

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION RENTON WASH

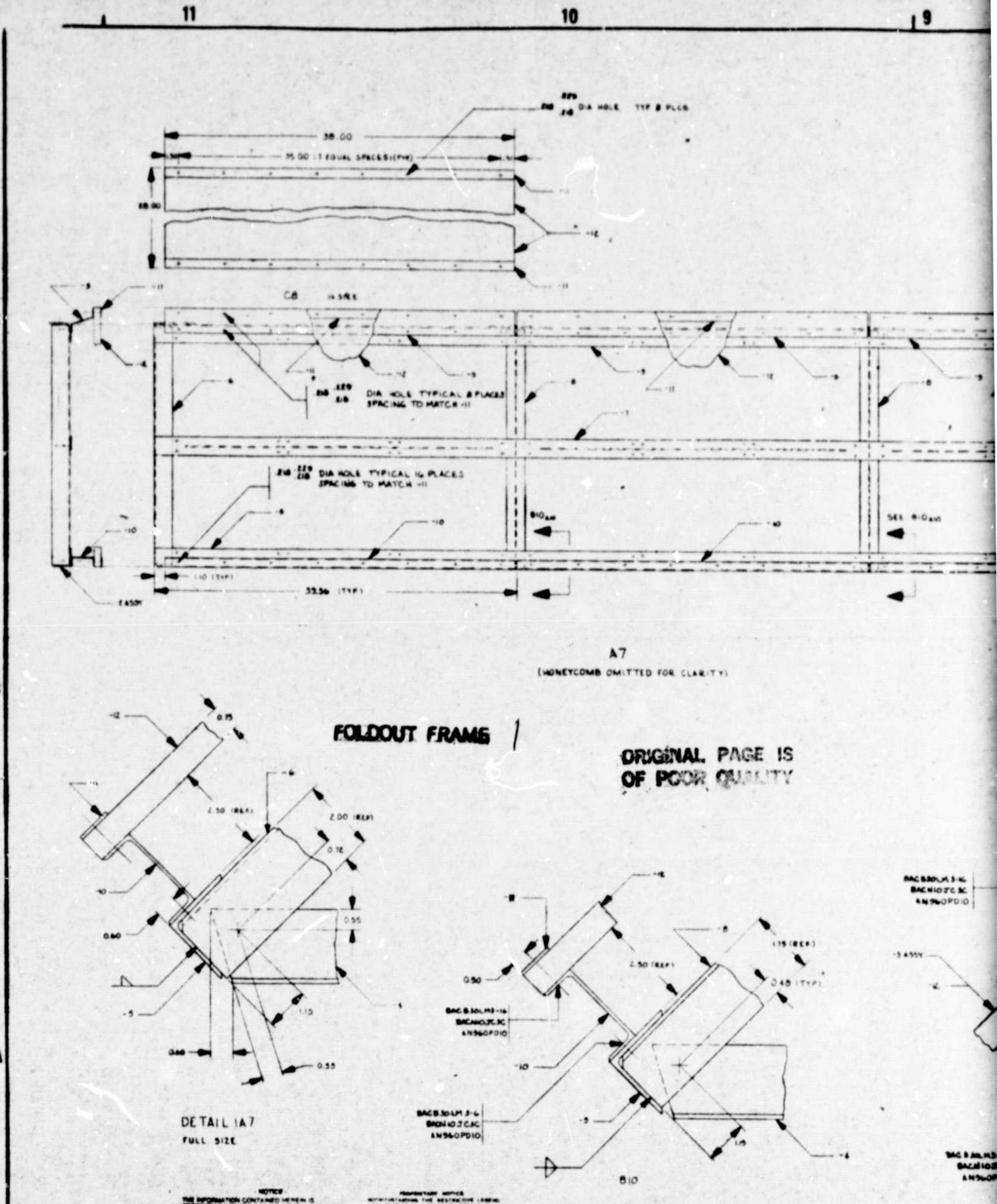
INSTALLATION-TENSION SPECIMEN HOLDER - ENVIRONMENTAL TEST

CODE IDENT NO 81205 | SIZE J | 65C19381

65C19381 SH 1

26

FIGURE A-3



FOLDOUT FRAME 1

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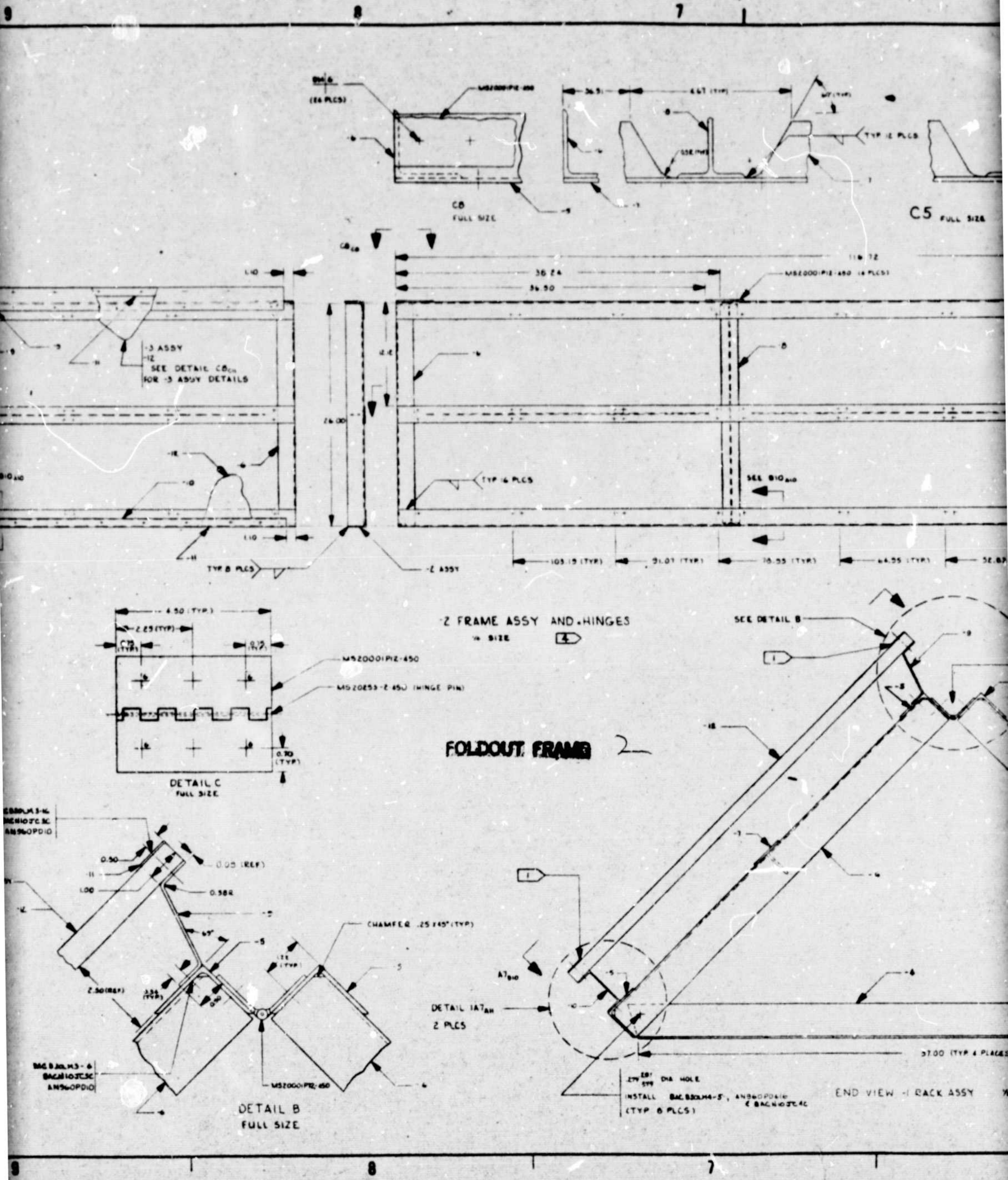
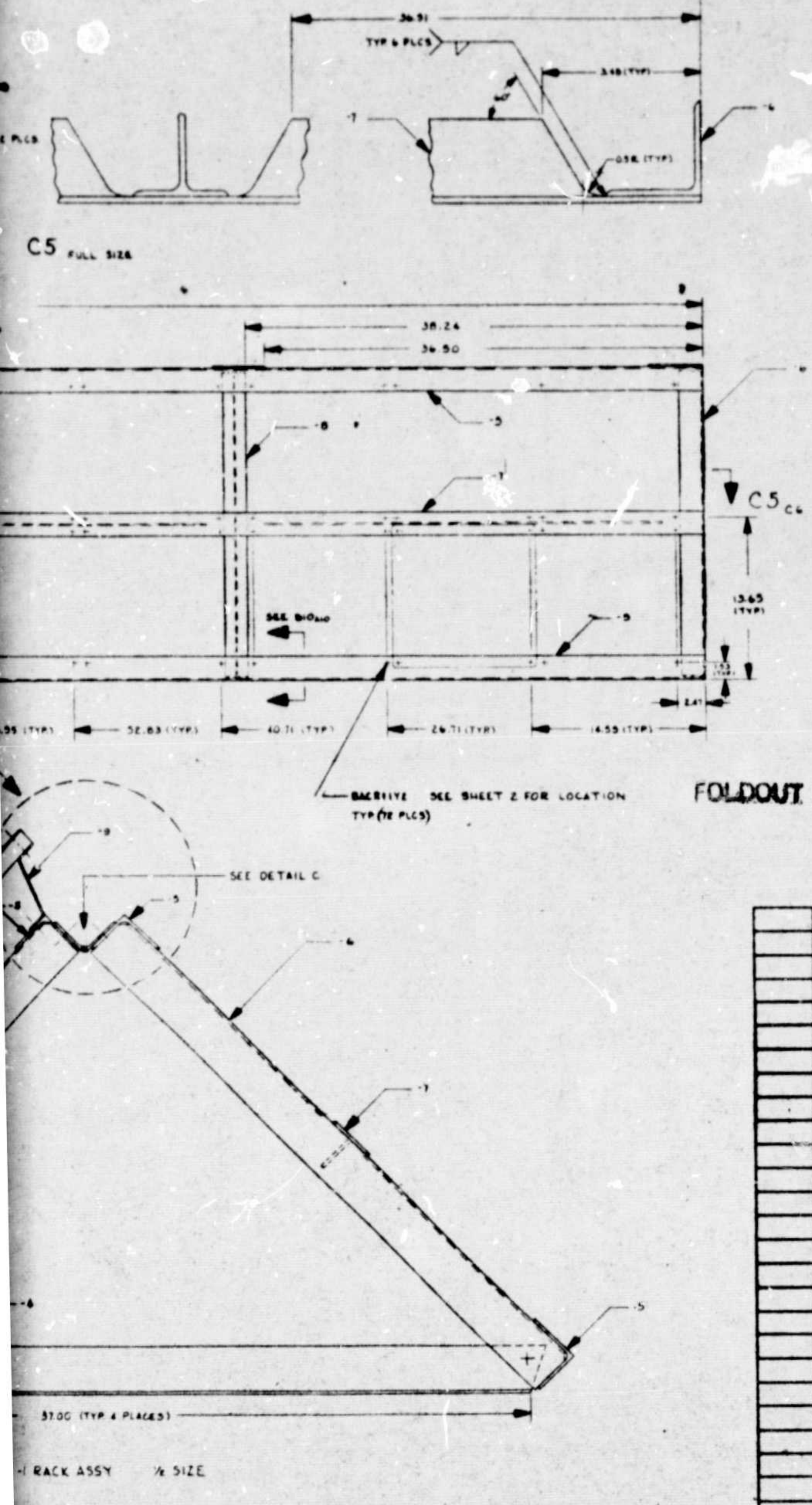
OF POOR QUALITY

65C19714



FOLDOUT FRAME 2



ORIGINAL PAGE IS
OF POOR QUALITY

FOLDOUT FRAME 3

									✓	8
									✓	102
									✓	8
									✓	102
									✓	8
									✓	48
									✓	48
									✓	18
									✓	18
									✓	4
									✓	36
									✓	4
									-3	1
									-3	2
									-3	1
									-3	1
									-2	2
									-2	1
									-2	2
									-2	2
									✓	4
									✓	3
									✓	2
									—	—
									-1	QTY REQD

RELEASE

65C19714 SH 1

3 2

DIMENSIONING & TOLERANCING PER USAS Y14.5
PART MARKING PER BAC 5307
SEE BACD 2007 FOR SURFACE ROUGHNESS
FORM, FINISH, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
BOLT & NUT INSTALLATION PER BAC 5009
MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 5000
SEE MATERIALS SUBSTITUTIONS & MANUFACTURING PROCESSES PER D6-19756
FOR FINISH CODES, SEE DOCUMENT

FASTENER SYMBOL CODE
INSTL STD PER BAC 5004, FLUID TIGHT PER BAC 5047
BASIC CODE — ENCLOSED = FLUID TIGHT; OPEN = STANDARD — DIA DASH NO — MFD HEAD LOC — N=NEAR SIDE, F=FAR SIDE
DIMPLE/CSK INFO — D=DIMPLE, ?=NO. OF DIMPLED, C=CSK INSTRUCTURE, ?LINES: TOP=MFD HD; BOTTOM=DRIVEN HD — SPOT WELD OPT — LENGTH DASH NO
NOTE: PROTRUDING HD RIVETS DRIVEN FLUSH. D/C INFO (2 LINES) APPLIES TO DRIVEN HD ONLY
HOLE LOCATION FOR 3/16 DIAMETER RIVET
HOLE LOCATION FOR 1/4 DIAMETER BOLT

FOLDOUT FRAME 4

ORIGINAL PAGE IS OF POOR QUALITY

5 HOLE PATTERN IN -14 OR -15 SPECIMEN MOUNT INSTALLATION POSITION ON -2 ASSY

4 ASSEMBLE -2 PRIOR TO HOLE DRILLING O

3 FINISH F-17.04 + 2 COATS PRIMER PER F-20

2 FINISH F-18.06 EXCEPT APPLY 2 COATS BM + SRF-14.9813

1 BOND PER BAC 5010 TYPE 44

	-1	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT-TR	FINISH	PT-MK	REV LTR
	✓	8	AN960PD416	WASHER						
	✓	102	AN960PD10	WASHER						
	✓	8	BACN10JC4C	NUT						
	✓	102	BACN10JC3C	NUT						
	✓	8	BACB30LM4-5	BOLT						
	✓	48	BACB30LM3-6	BOLT						
	✓	48	BACB30LM3-16	BOLT						
	✓	18	-15	SPECIMEN MOUNT		0.063×12.0×2.0 2024-T3 CLAD SHEET PER QQ-A-250/5		2	M	
	✓	18	-14	SPECIMEN MOUNT		0.063×12.0×2.0 2024-T3 CLAD SHEET PER QQ-A-250/5		2	M	
	✓	4	MS20253-2-450	HINGE PIN						
	✓	36	-13	CLAMP		0.063×0.9×11.2 2024-T3 CLAD SHEET PER QQ-A-250/5		2	M	
	✓	4	MS20001P12-450	HINGE				3	M	
	-3	1	-12	HONEYCOMB		HONEYCOMB CORE PER BMS 4-4 CLASS I, TYPE II GRADE 12 [illegible]				
	-3	2	-11	STRIP HONEYCOMB CLAMPING		0.09×1.0×38.0 2024-T3 CLAD SHEET PER QQ-A-250/5		2	M	
	-3	1	-10	CHANNEL		AND 10137-2401 [illegible] 2024-T3 PER QQ-A-267		3	M	
	-3	1	-9	Z-HONEYCOMB SUPT		0.09×4.5×38.0 2024-T3 CLAD SHEET PER QQ-A-250/5		2	M	
	-2	2	-8	TEE		AND 10136-2008×26.1 6061-T6511 PER QQ-A-200/8			M	
	-2	1	-7	TEE		AND 10136-2008×116.8 6061-T6511 PER QQ-A-200/8			M	
	-2	2	-6	ANGLE		AND 10133-2002×26.1 6061-T6511 PER QQ-A-200/8			M	
	-2	2	-5	ANGLE		AND 10133-2002×116.8 6061-T6511 PER QQ-A-200/8			M	
	✓	4	-4	ANGLE-BRACE		AND 10133-2002×38.5 6061-T6511 PER QQ-A-200/8			M	
	✓	3	-3	HONEYCOMB ASSY					M	
	✓	2	-2	FRAME ASSY				3		
	—	—		RACK ASSY					M	

LIST OF MATERIAL

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NEXT ASSY	USED ON	SECT NO	SERIAL NUMBER

APPLICATION

CONTRACT NO NAS1-15148

DWG ORIG BY (GROUP) ADVANCED STRUCTURAL CONCEPTS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± DECIMALS ±
RIVET & BOLT EDGE MARGINS ± .05
SHEET METAL CORNER RADII INTERNAL
EXTERNAL
BEND RADII: ± .01 ON .03 & .06; ± .03 ON .09 & GREATER

DRAWN	DATE
CHECKED	
STRESS	
ENGR	
GROUP	
PROJ	

3 2 1

REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPROVAL

FOLDOUT FRAME 5

PATTERN IN -14 OR -15 SPECIMEN MOUNT MUST FIT ANY
LLATION POSITION ON -2 ASSY

BLE -2 PRIOR TO HOLE DRILLING OPERATIONS

F-17.04 + 2 COATS PRIMER PER F-20.02 + SRF-14.9813

F-18.06 EXCEPT APPLY 2 COATS BMS 10-11 PRIMER

F-14.9813

PER BAC 5010 TYPE 44

NOTICE

PROPRIETARY NOTICE

USED ON	SECT NO	SERIAL NUMBER	PART NUMBER	RELEASE COLUMN INDICATOR	DRAWING SHEET NUMBER	REV LTR
APPLICATION						

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
ANGLES ± DECIMALS ±
RIVET & BOLT EDGE MARGINS ± .05
SHEET METAL CORNER RADII
INTERNAL

EXTERNAL

BEND RADII:
± .01 ON .02 & .06
± .03 ON .09 & GREATER

DRAWN | CHECKED | STRESS | ENGR | GROUP | PROJ | DATE

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION RENTON, WASH

ENVIRONMENTAL EXPOSURE RACK

CODE IDENT NO 81205 | SIZE J | 65C19714

SCALE | SH OF

DRAWING RECORDS CLERK

C

B

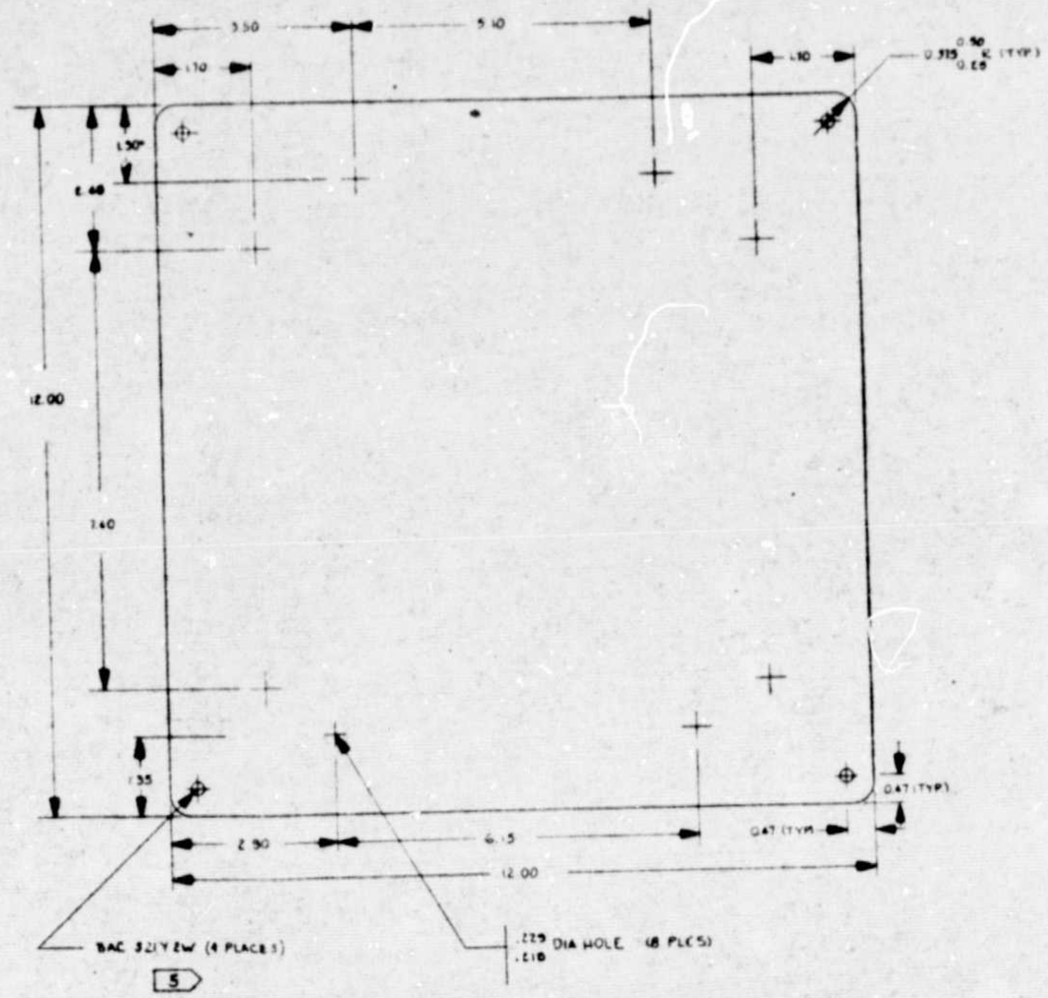
A

1

65C19714

27

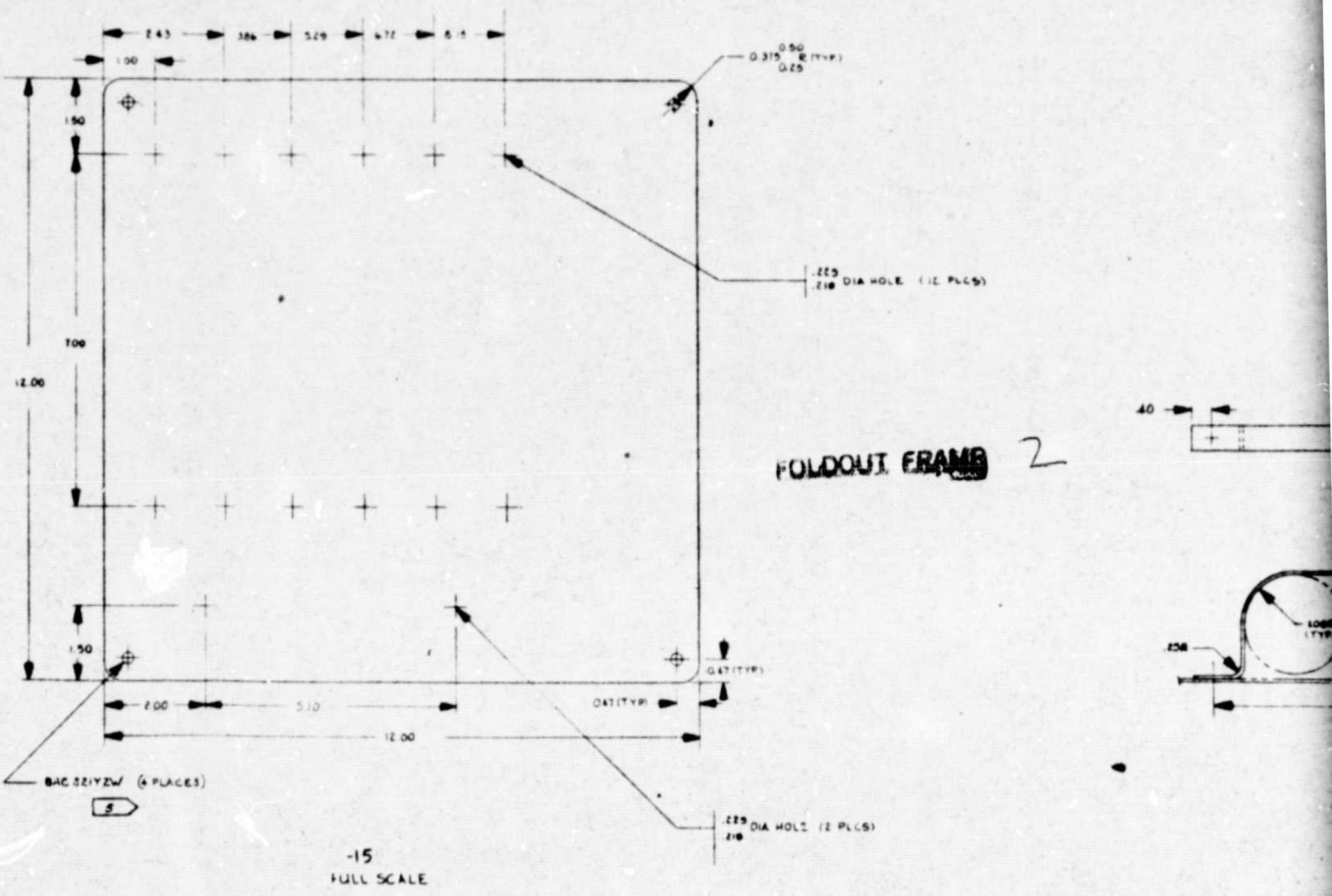
FIGURE A-4



-14
FULL SCALE

FOLDOUT FRAME

DIMENSIONING & TOLERANCING PER USAS Y14.5
PART MARKING PER BAC 5307
SEE BACD 2097 FOR SURFACE ROUGHNESS
FORM, FINISH, STRAIGHTEN & FIT METAL PARTS PER BAC 5300
BOLT & NUT INSTALLATION PER BAC 5009
MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 5000
SEE MATERIALS SUBSTITUTIONS & MANUFACTURING PROCESSES PER D6-49756
FOR FINISH CODES, SEE DOCUMENT D0-0000 & D6 5000



FOLDOUT FRAME 2

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		QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT-TR	FINISH	PT. MK.	REV LTR
RELEASE		LIST OF MATERIAL								

65C19714 SH 2

FASTENER SYMBOL CODE

NOTICE

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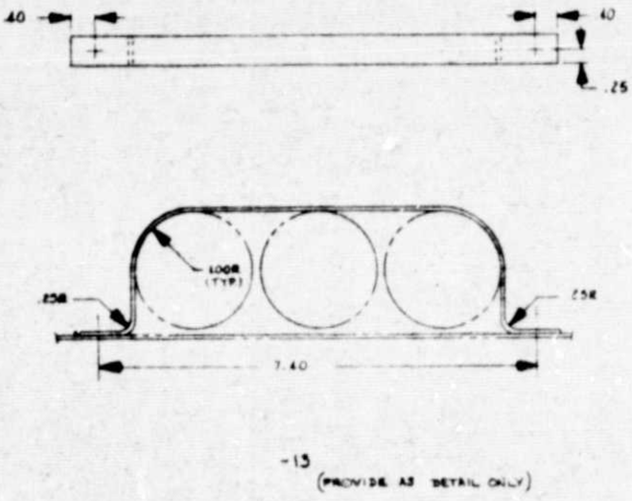

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FOLDOUT FRAME 3

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION RENTON, WASH

ENVIRONMENTAL EXPOSURE RACK

CONTRACT NO NAS1-15148

ADVANCED STRUCTURAL CONCEPTS

CODE IDENT NO 81205 SIZE J 65C19714

65C19714 2

28

FIGURE A-5